

# 03

## Refraction of Light

**TREND ANALYSIS** 3 YEARS

Average No. of Questions Across all Sets

TOPIC 01 Refraction of Light at Plane Surfaces

TOPIC 02 Total Internal Reflection

Types of Questions	2023	2020	2019
1 Mark	-	-	-
2 Marks	-	3	1
3 Marks	-	1	1
4 Marks	-	-	-
1 Mark	1	-	2
2 Marks	-	-	-
3 Marks	3	1	-
4 Marks	-	-	-

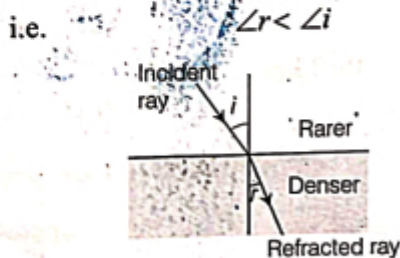
### TOPIC 1

## Refraction of Light at Plane Surfaces

The change in direction of light when it passes from one medium to another obliquely is called **refraction of light**.

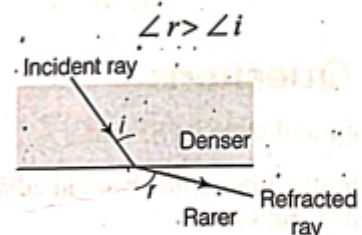
It has been found that

- (i) When a ray of light travels from a rarer medium to a denser medium, it bends towards the normal.



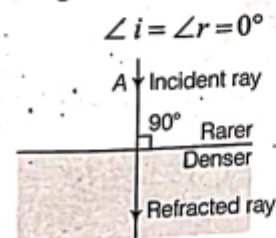
- (ii) When a ray of light travels from a denser medium to a rarer medium, it bends away from the normal.

i.e.



- (iii) The ray of light which is incident normally on the surface separating the two media, passes undeviated.

i.e.





## Causes of Refraction

The speed of light is different in different media. It is lesser in denser medium and greater in rarer medium. So, when light enters a denser medium, its speed reduces and it bends towards the normal and when it enters rarer medium, its speed increases and it bends away from the normal.

**Refracted Beam has Change in Speed ( $v$ ), Direction and Wavelength ( $\lambda$ ), While its Frequency ( $\nu$ ) Remains Constant**

- When a ray of light passes through a rarer to a denser medium, the speed of light ( $c$ ) decreases, while if it passes from a denser to a rarer medium, the speed of the light increases.
- Due to change in speed of light is passing from one medium to another, the direction of ray of light changes except for  $\angle i = 0$ .
- The frequency of light depends on the source of light, so it does not change on refraction.
- Due to refraction of light, the wavelength also changes, because its frequency remains unchanged.
- The relation between speed of light ( $c$ ), frequency ( $f$ ) and wavelength ( $\lambda$ ) is given by

$$c = f\lambda$$

Value of speed of light in air/vacuum =  $3 \times 10^8$  m/s

Value of speed of light in water =  $2.25 \times 10^8$  m/s

Value of speed of light in glass =  $2.00 \times 10^8$  m/s

## Laws of Refraction

- First law** The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.
- Second law** The ratio of sine of angle of incidence to the sine of angle of refraction is constant for a given pair of media. This constant is known as refractive index of the second medium w.r.t. first medium. It is expressed as  ${}_1\mu_2 = \frac{\sin i}{\sin r} = \text{constant}$

This is also known as **Snell's law**.

## Relation between Refractive Index and Velocity of Light

The refractive index of the medium is the ratio of the velocity of light in vacuum (or air) to the velocity of light in that medium.

$$\mu = \frac{\text{Velocity of light in vacuum, } (c)}{\text{Velocity of light in medium, } (v)}$$

## Relation between Refractive Index and Wavelength

$$\mu = \frac{\text{Speed of light in air } (c)}{\text{Speed of light in medium } (v)} = \frac{f\lambda_0}{f\lambda}$$

$$\Rightarrow \mu = \frac{\lambda_0}{\lambda} \Rightarrow \lambda = \frac{\lambda_0}{\mu}$$

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

where,  $\lambda$  = wavelength of the light in air  
and  $\mu$  = refractive index of medium.

## Principle of Reversibility of Light

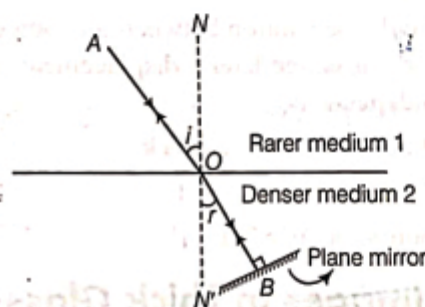
This principle states that, the path of light ray is reversible.

For light ray moving from rarer medium 1 to denser medium 2, incidence angle is  $i$  and angle of refraction is  $r$ .

According to Snell's law,

$${}_1\mu_2 = \frac{\sin i}{\sin r} \quad \dots (i)$$

Suppose a plane mirror is placed perpendicular to the path of ray  $OB$ . This reverses the ray along its own path in this case, angle of incidence is  $r$  and angle of refraction is  $i$ .



According to Snell's law,

$${}_2\mu_1 = \frac{\sin r}{\sin i} \quad \dots (ii)$$

On multiplying Eqs. (i) and (ii), we get

$${}_1\mu_2 \times {}_2\mu_1 = \frac{\sin i}{\sin r} \times \frac{\sin r}{\sin i} = 1$$

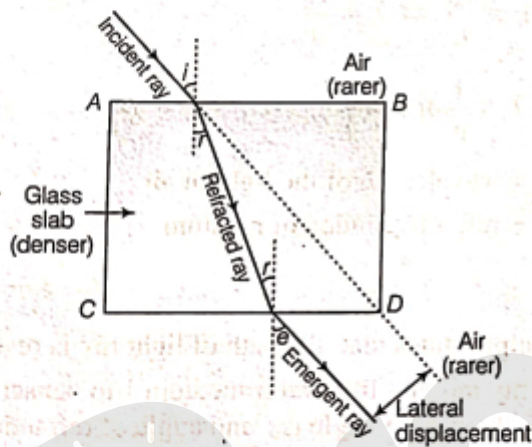
$$\therefore {}_1\mu_2 = \frac{1}{{}_2\mu_1}$$

This is known as reversibility principle.



## Refraction of Light Through a Glass Slab

When a light ray enters in a glass slab, then the emergent ray is parallel to the incident ray but it is shifted sideward slightly. In this case, refraction takes place twice, first when ray of light enters glass slab from air and second when ray of light exits from glass slab to air.



So, the ray emerges parallel to incident ray but shifted sideward slightly.

where,  $i$  = Angle of incidence,  $r$  = Angle of refraction and  $e$  = Angle of emergence.

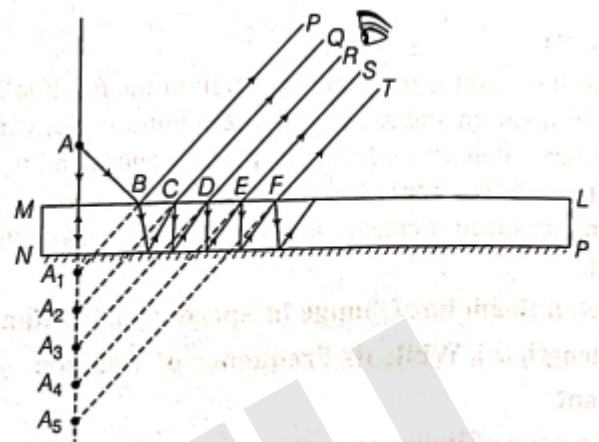
### Lateral Displacement

The perpendicular separation between the incident ray and the emergent ray is called lateral displacement. The lateral displacement depends on

- (i) the thickness of the glass block.
- (ii) the angle of incidence.
- (iii) the refractive index of glass.

## Multiple Images in Thick Glass Plate/Mirror

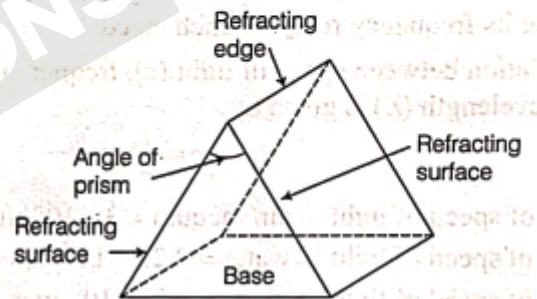
If a pin  $A$  is placed in front of a thick plane glass plate/thick mirror and is viewed obliquely, a number of images are seen. Out of all these images, the second image  $A_2$  is the brightest while others are of diminishing brightness.



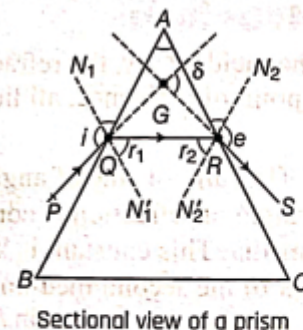
## Refraction of Light Through a Prism

Prism is a transparent refracting medium bound by two plane surfaces, inclined to each other at certain angle ( $60^\circ$  or  $45^\circ$ ) as shown in the adjacent figure.

It has two triangular bases and three rectangular lateral surfaces. The angle between two lateral surfaces is called **angle of prism ( $A$ )**.



The figure below shows refraction through a prism.



where,  $PQ$  = Incident ray,  
 $QR$  = Refracted ray



$RS$  = Emergent ray,  $\angle A$  = Angle of prism  
 $\angle i_1$  = Angle of incidence,  $\angle r_1, \angle r_2$  = Angles of refraction  
 $\angle e$  = Angle of emergence  
 and  $\angle \delta$  = Angle of deviation.

**NOTE** When a ray of light passes through a prism, it bends towards the thicker part of the prism.

### Angle of Deviation ( $\delta$ )

It is the angle by which the emergent ray (produced backward) makes with the incident ray (produced forward). It depends upon the angle of prism.

### Different Relations of Angle in the Prism

The different relations of angle in the prism are as follows

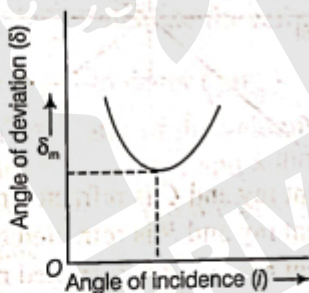
(i)  $\delta = (i + e) - (r_1 + r_2)$

(ii)  $i + e = A + \delta$

(iii)  $r_1 + r_2 = A$

where,  $i$  = Angle of incidence,  
 $e$  = Angle of emergence,  
 $\delta$  = Angle of deviation,  
 $A$  = Angle of prism and  
 $r_1, r_2$  = Angles of refraction.

The relation between angle of incidence and angle of deviation can be represented through the graph as given below.



### Angle of Minimum Deviation

In the position of minimum deviation, the refracted ray inside the prism travels parallel to its base, if the prism is equilateral.

Thus, the position of minimum deviation is

$$\delta = \delta_{\min}, i = e = i$$

Then, the equation is  $i + e = A + \delta$

$$\delta_{\min} = 2i - A$$

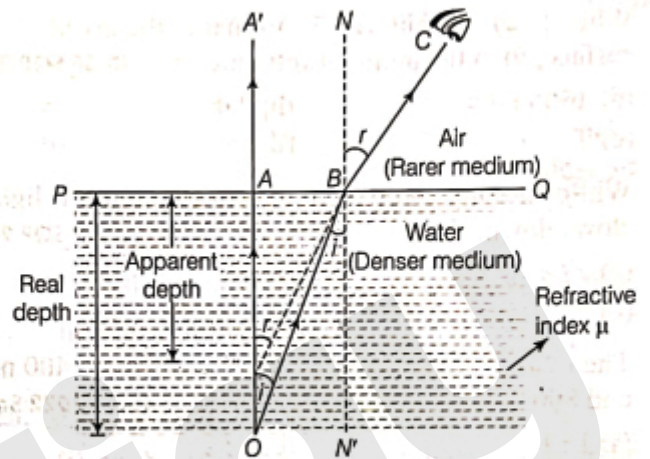
Relation between deviation angle ( $\delta$ ) and refractive index of prism material ( $\mu$ )

$$\delta = (\mu - 1) A$$

## Simple Applications

### Real and Apparent Depth of Objects in Water

According to the situation shown in the figure,



$$\text{Refractive index } \mu = \frac{OA}{IA} = \frac{\text{Real depth}}{\text{Apparent depth}}$$

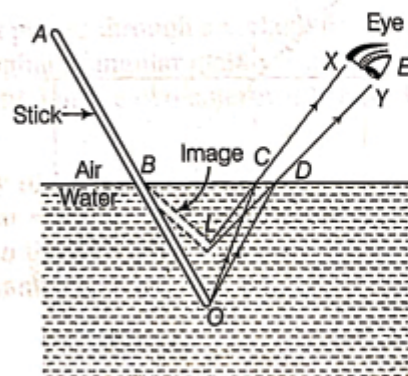
$$\Rightarrow \text{Apparent depth} = \frac{\text{Real depth}}{\mu}$$

$$\text{Shift } (OI) = \text{Real depth} - \text{Apparent depth}$$

$$\Rightarrow \text{Shift} = \text{Real depth} \times \left(1 - \frac{1}{\mu}\right)$$

### Apparent Bending of a Stick Under Water

Consider a straight stick  $ABO$ , which is placed obliquely in water. The portion of the stick  $OB$  under water appears to be shortened and raised up as  $LB$ . This is due to refraction of light passing from water to air.



The rays of light coming from tip  $O$  of the stick when passing from water to air, bend away from the normal and appear to be coming from a point  $L$ , which is the virtual image of the point  $O$ . It is true for every point of the stick inside the water.

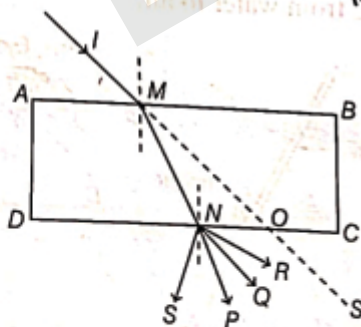


**PYQs**

**Previous Years Questions**

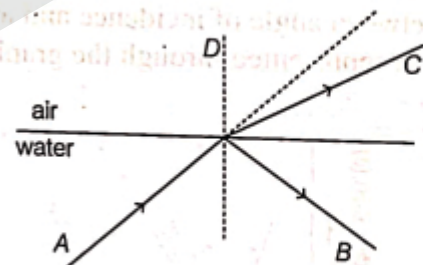
**1 Mark Questions**

- When a ray of light travels normal to the given surface, then the angle of refraction is (ICSE SQP 2023)
  - $180^\circ$
  - $90^\circ$
  - $0^\circ$
  - $45^\circ$
- While entering from medium *A* to medium *B* if light slows down, then (ICSE SQP 2023)
  - $\angle i < \angle r$
  - $\angle i = \angle r$
  - $\angle i > \angle r$
  - $\angle i \leq \angle r$
- The ratio of velocities of light of wavelength 400 nm and 800 nm in a vacuum is (ICSE 2022 Sem-I)
  - 1 : 1
  - 1 : 2
  - 2 : 1
  - 1 : 3
- The refractive index of a diamond is 2.4. It means that, (ICSE 2022 Sem-I)
  - the speed of light in vacuum is equal to  $\frac{1}{24}$  times the speed of light in diamond
  - the speed of light in diamond is 2.4 times the speed of light in vacuum
  - the speed of light in vacuum is 2.4 times the speed of light in diamond
  - the wavelength of light in diamond is 2.4 times the wavelength of light in vacuum
- A ray of light *IM* is incident on a glass slab *ABCD* as shown in the figure. The emergent ray for this incident ray is (ICSE 2022 Sem-I)



- NQ*
- NR*
- NP*
- NS*

- Choose the correct statement with respect to refraction of light. (ICSE SQP 2022 Sem-I)
  - The frequency always changes when light enters from one optical medium to another.
  - Absorption of light when it strikes the surface of a medium is refraction.
  - Speed of light changes when it enters from one optical medium to another of different optical density.
  - Speed of light does not change when it enters from one optical medium to another of different optical density.
- When a light ray enters from a denser medium to a rarer medium (ICSE SQP 2022 Sem-I)
  - The light ray bends towards the normal.
  - Angle of incidence is less than angle of refraction.
  - Speed of light decreases.
  - Speed of light remains unchanged.
- In the diagram shown below (ICSE SQP 2021)

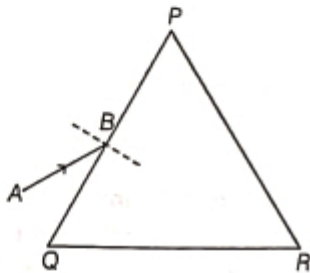


- B* is incident ray and *C* is refracted ray.
  - A* is incident ray and *B* is refracted ray.
  - C* is incident ray and *B* is refracted ray.
  - A* is incident ray and *C* is refracted ray.
- Name one factor that affects the lateral displacement of light as it passes through a rectangular glass slab. (ICSE 2015)
  - Does the depth of a tank of water appear to change or remain the same when viewed normally from above? (ICSE 2012)
  - How does the speed of light in glass change on increasing the wavelength of light? (ICSE 2007)

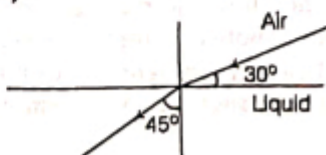


## 2 Marks Questions

12. A pond appears to be 2.7 m deep. If the refractive index of water is  $\frac{4}{3}$ , find the actual depth of the pond. (ICSE 2020)
13. Complete the path of the monochromatic light ray  $AB$  incident on the surface  $PQ$  of the equilateral glass prism  $PQR$  till it emerges out of the prism due to refraction. (ICSE 2020)



14. A ray of light falls normally on a rectangular glass slab. Draw a ray diagram showing the path of the ray till it emerges out of the slab. (ICSE 2020)
15. (i) What is the relation between the refractive index of water with respect to air ( ${}_a\mu_w$ ) and the refractive index of air with respect to water ( ${}_w\mu_a$ )?  
 (ii) If the refractive index of water with respect to air ( ${}_a\mu_w$ ) is  $\frac{5}{3}$ . Calculate the refractive index of air with respect to water ( ${}_w\mu_a$ ). (ICSE 2019)
16. (i) Why is the ratio of the velocities of light of wavelengths 4000 Å and 8000 Å in vacuum 1 : 1 ?  
 (ii) Which of the above wavelengths has a higher frequency? (ICSE 2018)
17. How is the refractive index of a material related to  
 (i) real and apparent depth?  
 (ii) velocity of light in vacuum or air and the velocity of light in a given medium? (ICSE 2017, 11)
18. Draw a ray diagram to show the refraction of a monochromatic ray through a prism when it suffers minimum deviation. (ICSE 2017)



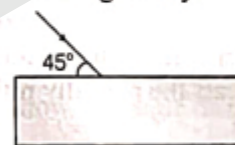
20. When a ray of light passes from air to glass, for what angle of incidence, the ray will not be deviated. (ICSE SQP 2017)
21. Draw a ray diagram to illustrate how a ray of light incident obliquely on one face of a rectangular glass slab of uniform thickness emerges. (ICSE SQP 2017)
22. A coin at the bottom of a trough containing water to a depth of 15 cm appears to be 3.75 cm raised above from the bottom. Calculate the refractive index of water. (ICSE SQP 2017)



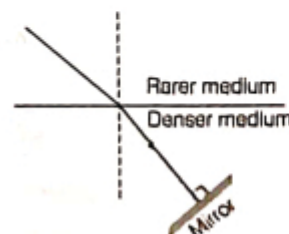
### KEY Idea

You can find the value of refractive index ( $\mu$ ) with the help of following formula,  $\mu = \frac{\text{Real depth}}{\text{Apparent depth}}$

23. State the dependence of angle of deviation  
 (i) on the refractive index of the material of the prism.  
 (ii) on the wavelength of light. (ICSE 2016)
24. The speed of light in glass is  $2 \times 10^5$  km/s. What is the refractive index of glass? (ICSE 2015)
25. Draw the diagram given below and clearly show the path taken by the emergent ray. (ICSE 2014)



26. (i) A ray of light passes from water to air. How does speed of light change?  
 (ii) Which colour of light travels fastest in any medium except air? (ICSE 2014)
27. Light passes through a rectangular glass slab and through a triangular glass prism. In what way, does the direction of the two emergent beams differ and why? (ICSE 2014)
28. A ray of light is moving from a rarer medium to a denser medium and strikes a plane mirror placed at  $90^\circ$  to the direction of the ray as shown in the diagram.



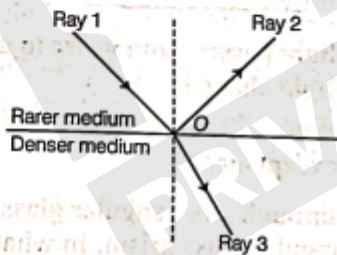


- (i) Copy the diagram and mark arrows to show the path of the ray of light after it is reflected from the mirror.
- (ii) Name the principle you have used to mark the arrow to show the direction of the ray. (ICSE 2013)

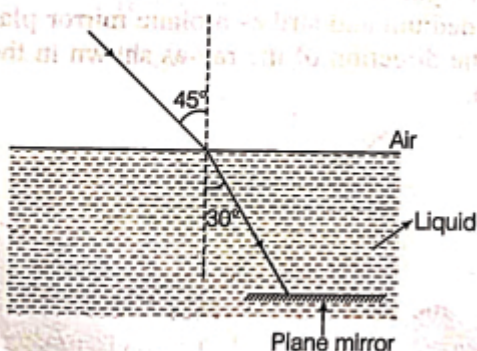
29. (i) The refractive index of glass with respect to air is 1.5. What is the value of the refractive index of air with respect to glass?
- (ii) A ray of light is incident as a normal ray on the surface of separation of two different mediums. What is the value of the angle of incidence in this case? (ICSE 2013)

30. A ray of light incident at an angle of incidence  $i$  passes through an equilateral glass prism such that the refracted ray inside the prism is parallel to its base and emerges from the prism at an angle of emergence  $e$ .
- (i) How is the angle of emergence  $e$  related to the angle of incidence  $i$ ?
  - (ii) What can you say about the value of the angle of deviation in such a situation? (ICSE 2012)

31. (i) Define the term refractive index of a medium in terms of velocity of light.
- (ii) A ray of light moves from a rarer medium to a denser medium as shown in the diagram alongside. Write down the number of the ray which represents the partially reflected ray. (ICSE 2012)

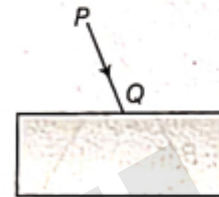


32. A ray of monochromatic light enters in a liquid from air as shown in the diagram given below.



- (i) Copy the diagram and show in the diagram the path of the ray of light after it strikes the mirror and re-enters the medium of air.
- (ii) Mark in your diagram, the two angles on the surface of separation, when the ray of light moves out from the liquid to air. (ICSE 2011)

33. In the given diagram,  $PQ$  is a ray of light incident on a rectangular glass block.



- (i) Copy the diagram and complete the path of the ray of light through the glass block. In your diagram, mark the angle of incidence by letter  $i$  and the angle of emergence by the letter  $e$ .
- (ii) How are the angles  $i$  and  $e$  related to each other? (ICSE 2011)

34. The refractive index of diamond is 2.42. What is meant by this statement? (ICSE 2010)

35. (i) What is meant by refraction of light?
- (ii) What is the cause of refraction of light? (ICSE 2010)

36. A ray of light strikes the surface of a rectangular glass block such that the angle of incidence is (i)  $0^\circ$  and (ii)  $42^\circ$ . Sketch a diagram to show the approximate path taken by the ray in each case as it passes through the glass block and emerges. (ICSE 2009)

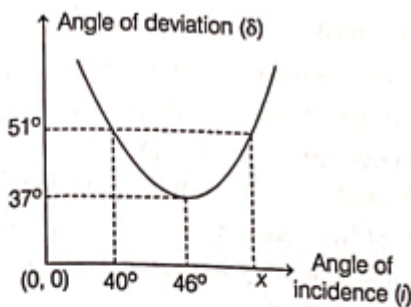
37. (i) A monochromatic beam of light of wavelength  $\lambda$  passes from air into a glass block. Write an expression to show the relation between the speed of light in air and the speed of light in glass.
- (ii) As the ray of light passes from air to glass, state how the wavelength of light changes. Does it increase, decrease or remain constant? (ICSE 2008)

38. The velocity of light in diamond is 121000 km/s. What is its refractive index? (Take, velocity of light in air is  $3 \times 10^8$  m/s) (ICSE 2003)

### 3 Marks Questions

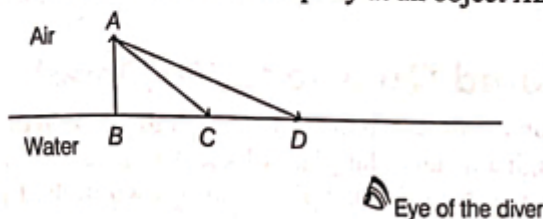
39. The diagram (not drawn to the scale) below shows the graphical relation between angle of deviation and angle of incidence, when light passes through a triangular prism of angle  $62^\circ$  of a certain glass material.





- (i) State the angle of minimum deviation of this prism and the corresponding angle of incidence.  
 (ii) Calculate the value of  $X$ . (ICSE SQP 2023)

40. A diver in water looks obliquely at an object  $AB$  in air.



- (i) Does the object appear taller, shorter or of the same size to the diver?  
 (ii) Show the path of two rays  $AC$  and  $AD$  starting from the tip of the object as it travels towards the diver in water and hence obtain the image of the object. (ICSE 2020)

41. How does the angle of deviation formed by a prism change with the increase in the angle of incidence?

Draw a graph showing the variation in the angle of deviation with the angle of incidence at a prism surface. (ICSE 2019)

42. What is understood by lateral displacement? State two factors on which it depends. (ICSE 2018)

43. (i) Write a relationship between angle of incidence and angle of refraction for a given pair of media.  
 (ii) When a ray of light enters from one medium to another having different optical densities it bends. Why does this phenomenon occur?  
 (iii) Write one condition, where ray of light does not bend when entering in a medium of different optical density. (ICSE 2016)

44. (i) Can the absolute refractive index of a medium be less than one?  
 (ii) A coin placed at the bottom of a beaker appears to be raised by 4.0 cm. If the refractive index of water is  $4/3$ , then find the depth of the water in the beaker. (ICSE 2013)

45. (i) State the laws of refraction of light.  
 (ii) Write a relation between the angle of incidence ( $i$ ), angle of emergence ( $e$ ), angle of prism ( $A$ ) and angle of deviation ( $\delta$ ) for a ray of light passing through an equilateral prism. (ICSE 2011)

46. A stick partly immersed in water appears to be bent. Draw a ray diagram to show the bending of the stick when placed in water and viewed obliquely from above. (ICSE 2010)

47. A ray of monochromatic light is incident from air on a glass slab.

- (i) Draw a labelled ray diagram showing the change in the path of the ray till it emerges from the glass slab.  
 (ii) Name the two rays that are parallel to each other.  
 (iii) Mark the lateral displacement in your diagram. (ICSE 2010)

48. How does the value of angle of deviation produced by a prism change with an increase in the

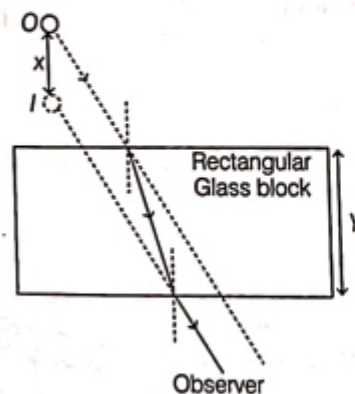
- (i) value of angle of incidence  
 (ii) wavelength of incident light? (ICSE 2009)

49. A prism deviates a monochromatic ray of light through an angle  $\delta$ , where the angle of incidence at the surface of the prism is  $i$ .

- (i) Draw a graph showing the variation of  $\delta$  with  $i$ . On your graph, show the angle of minimum deviation.  
 (ii) What is the relation between the angle of incidence and the angle of emergence when the ray suffers minimum deviation. (ICSE 2002)

## 4 Marks Questions

50.



The above diagram shows that an observer sees the image of an object  $O$  at  $I$ .

- (i) Name and define the phenomenon responsible for seeing the image at a different position.



- (ii) State the effect on  $X$  when (ICSE SQP 2023)  
(a)  $Y$  increases (b)  $Y$  decreases
51. Jatin puts a pencil into a glass container having water and is surprised to see the pencil in a different state.  
(i) What change is observed in the appearance of the pencil?  
(ii) Name the phenomenon responsible for the change.  
(iii) Draw a ray diagram showing how the eye sees the pencil. (ICSE 2015)
52. The diagram given below shows a ray of light incident on an equilateral glass prism placed in minimum deviation position.

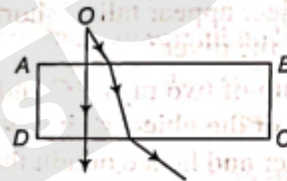


- (i) Copy the diagram and complete it to show the path of the refracted ray and the emergent ray.  
(ii) How are angle of incidence and angle of emergence related to each other in this position of the prism? (ICSE 2008)
53. (i) With the help of a well-labelled diagram, show that the apparent depth of an object such as a coin in water is less than its real depth.  
(ii) How is the refractive index of water related to the real depth and the apparent depth of a column of water? (ICSE 2007)
54. (i) State Snell's laws.  
(ii) Calculate the velocity of light in a glass block of refractive index 1.5. (Take, velocity of light in air =  $3 \times 10^8$  m/s) (ICSE 2007, 04)

55. (i) What is meant by refraction?  
(ii) Express the refractive index  $\mu$  of a medium  
(a) in terms of the velocity of light.  
(b) in terms of the angle of incidence  $i$  in air and the angle of refraction  $r$  in a denser medium.  
(iii) If a ray of light passes from one medium to other medium without any change of direction. What can be said about the refractive indices of these media (angle  $i$  is not zero)? (ICSE 2005)
56. A postage stamp appears raised by 7.0 mm, when placed under a rectangular glass block of refractive index 1.5. Find the thickness of the glass block. (ICSE 2003)

### Structured Questions (10 Marks)

57. A monochromatic point source of light  $O$  is seen through a rectangular glass block  $ABCD$ . Paths of two rays, in and outside the block, are shown in the figure alongside.



- (i) Does the source at point  $O$  appear to be nearer or farther with respect to the surface  $AB$ ? (2)  
(ii) How does the shift depend on the thickness ( $AD$  or  $BC$ ) of the block? (2)  
(iii) Justify your answer with the help of an appropriate ray diagram as shown in part (ii). (3)  
(iv) For the same rectangular glass block, which colour from the visible spectra will produce the maximum shift? (ICSE 2003) (3)



## TOPIC 2

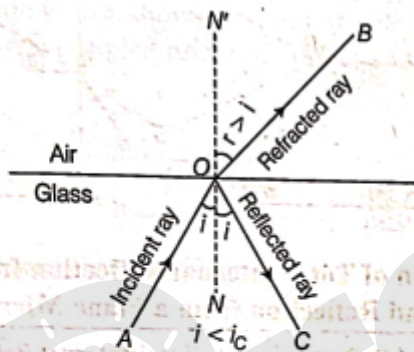
# Total Internal Reflection

### Transmission of Light from a Denser Medium (Glass) to a Rarer Medium (Air)

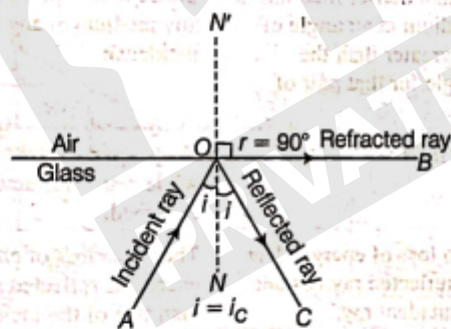
When a ray of light travelling in a denser medium (glass) falls on the surface separating it from the rarer medium (air), it is partly reflected back into the denser medium and partly refracted in the rarer medium. The refracted ray bends away from the normal on the surface at the point of incidence satisfying the laws of refraction.

The following cases arise

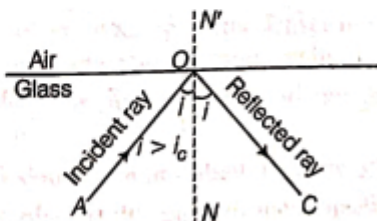
**Case 1** When the angle of incidence is less than critical angle, ( $i < i_c$ )



**Case 2** When the angle of incidence is equal to critical angle, ( $i = i_c$ )



**Case 3** When the angle of incidence is greater than critical angle, ( $i > i_c$ )



### Critical Angle

It is the angle of incidence in the denser medium corresponding to which the angle of refraction in the rarer medium is  $90^\circ$ . It is denoted by  $i_c$ .

The critical angle is affected by the following two factors

- (i) The colour of the light
- (ii) The temperature

### Relation between Critical Angle and Refractive Index

We know that, a refractive index of rarer medium w.r.t.

denser medium,  ${}_d\mu_r = \frac{\sin i}{\sin r}$

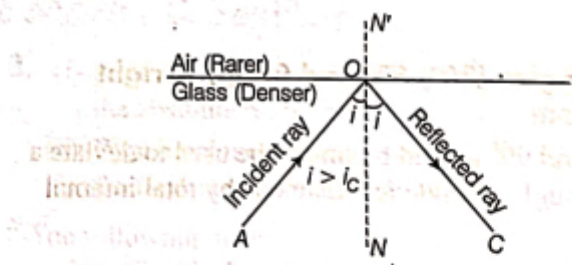
If  $i = i_c$  and  $r = 90^\circ$ , then  ${}_d\mu_r = \frac{\sin i_c}{\sin 90^\circ}$

$$\Rightarrow {}_d\mu_r = \sin i_c \Rightarrow {}_r\mu_d = \frac{1}{\sin i_c}$$

where,  $r$  is rarer medium and  $d$  is denser medium.

### Total Internal Reflection

It is the phenomenon due to which a ray of light travelling in a denser medium, is incident at the surface of a rarer medium such that the angle of incidence is greater than the critical angle for the pair of media, the ray is totally reflected back into the denser medium.



### Essential Conditions for Total Internal Reflection

The necessary conditions for the total internal reflection are

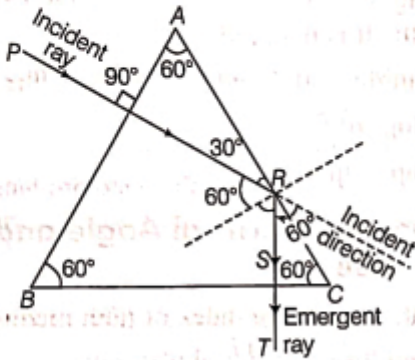
- (i) The light must travel from a denser medium to a rarer medium.
- (ii) The angle of incidence must be greater than the critical angle for the pair of media.



## Total Internal Reflection in Triangular Glass Prism

**Prism of each angle is  $60^\circ$ , i.e. equilateral prism**

A prism of each angle  $60^\circ$  can be used to deviate a light ray through  $60^\circ$  by total internal reflection.



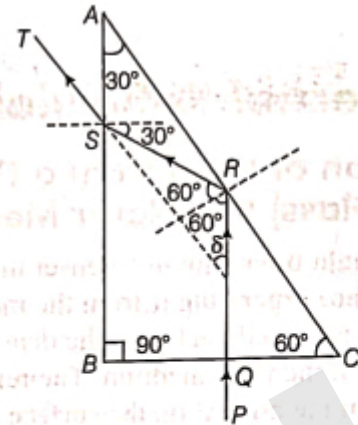
**Prism of angles  $(45^\circ, 45^\circ$  and  $90^\circ)$ , i.e. right angled isosceles prism**

A prism having an angle of  $90^\circ$  between its two refracting surfaces and the two other angles each of  $45^\circ$  suffers total internal reflection inside the prism.

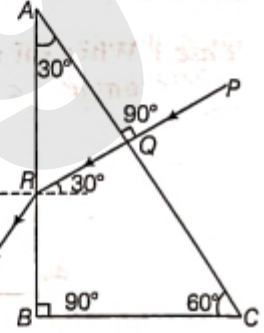
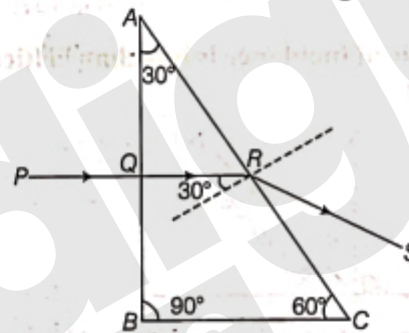


**Prism of angles  $(30^\circ, 60^\circ$  and  $90^\circ)$ , i.e. right angled prism**

A  $30^\circ, 60^\circ$  and  $90^\circ$  angled prism can be used to deviate a light ray through an angle less than  $60^\circ$  by total internal reflection.



No internal reflection through  $30^\circ, 60^\circ$  and  $90^\circ$ .



## Comparison of Total Internal Reflection from a Prism and Reflection from a Plane Mirror

### Total Internal Reflection from a Prism

It takes place only when light passes from a denser medium to a rarer medium at an angle of incidence greater than the critical angle for that pair of media.

The entire light is reflected.

There is no loss of energy. The energy of reflected ray is same as that of incident ray.

### Total Internal Reflection from a Plane Mirror

It takes place when light is incident on a plane mirror from any medium at any angle of incidence.

Only a part of light is reflected while rest is refracted and absorbed.

There is a loss of energy. The energy of reflected ray is less than that of the incident ray.



# PYQs Previous Years Questions

## 1 Mark Questions

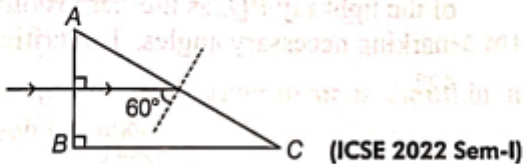
1. Small air bubbles rising up a fish tank appear silvery when viewed from some particular angle is due to the  
(ICSE 2023)

- (a) reflection (b) refraction  
(c) dispersion (d) total internal reflection

2. The phenomenon of light that causes the diamond to glitter is  
(ICSE SQP 2023)

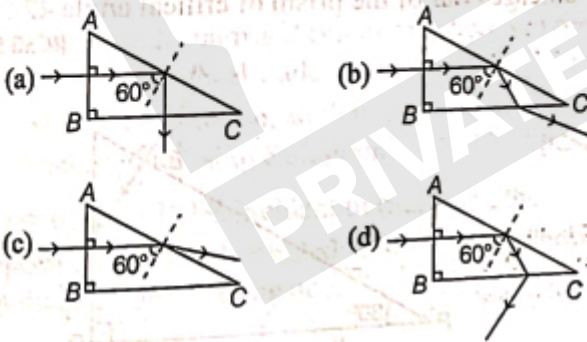
- (a) refraction (b) total internal reflection  
(c) reflection (d) absorption

3. The diagram below shows the path of light passing through a right-angled prism of critical angle  $42^\circ$ .



- (i) The angle  $C$  of the prism is  
(a)  $45^\circ$  (b)  $60^\circ$   
(c)  $90^\circ$  (d)  $30^\circ$

(ii) Which one of the following diagrams show the correct path of this ray till it emerges out of the prism?



4. Select correct options for total internal reflection in a medium.  
(ICSE SQP 2022 Sem-I)

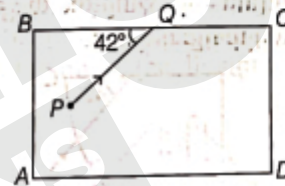
- (a) Can take place in an optically denser medium as compared to an optically rarer medium.  
(b) Takes place for any angle of incidence greater than  $42^\circ$  degree.  
(c) This reflection does not obey the laws of reflection.  
(d) Can take place if the angle of incidence in a denser medium is less than the critical angle.

5. Diamonds glitter in the dark because  
(ICSE SQP 2022 Sem-I)

- (a) They emit light.  
(b) They have a very small critical angle due to very high refractive index.  
(c) Due to the fluorescence.  
(d) Chemical reaction in the diamond produces light energy.

6. (i) Define critical angle.  
(ii) State one important factor which affects the critical angle of a given medium.  
(ICSE 2019)

7. The diagram below shows a light source  $P$  embedded in a rectangular glass block  $ABCD$  of critical angle  $42^\circ$ . Complete the path of the ray  $PQ$  till it emerges out of the block. [Write necessary angles].  
(ICSE 2019)



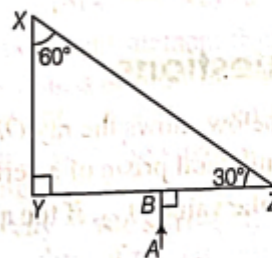
### KEY Idea

To solve this question, you should use the conditions of total internal reflection.

## 2 Marks Questions

8. (i) State the relation between the critical angle and the absolute refractive index of a medium.  
(ii) Which colour of light has a higher critical angle? Red light or green light.  
(ICSE 2018)

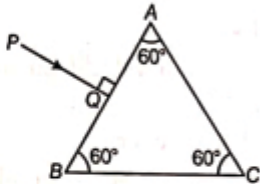
9. The following diagram shows a  $60^\circ, 30^\circ, 90^\circ$  glass prism of critical angle  $42^\circ$ . Copy the diagram and complete the path of incident ray  $AB$  emerging out of the prism marking the angle of incidence on each surface.  
(ICSE 2018)





10. State the conditions required for the total internal reflection of the light to take place. (ICSE 2017, 09)

11. Copy the diagram given below and complete the path of the light ray till it emerges out of the prism. The critical angle of the glass is  $42^\circ$ . In your diagram, mark the angles wherever necessary. (ICSE 2016)



12. Name the factors affecting the critical angle for the pair of media. (ICSE 2014)

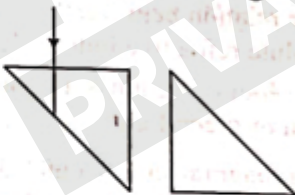
13. (i) What is meant by the term critical angle?  
(ii) How is it related to the refractive index of the medium? (ICSE 2012)

14. A ray of light enters a glass slab PQRS, as shown in the diagram. The critical angle of the glass is  $42^\circ$ . Copy this diagram and complete the path of the ray till it emerges from the glass slab.



Mark the angles in the diagram wherever necessary. (ICSE 2010)

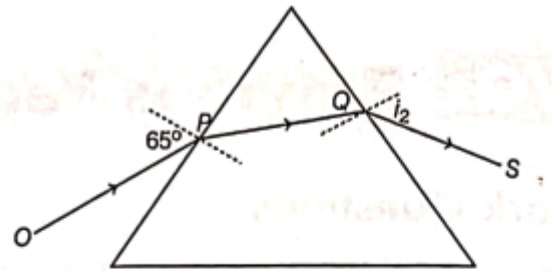
15. Two isosceles right-angled glass prisms are placed near each other as shown in the figure.



Complete the path of the light ray entering the first isosceles right-angled glass prism till it emerges from the second identical prism. (ICSE 2008)

### 3 Marks Questions

16. The diagram below shows the ray OP travelling through an equilateral prism of a certain material.  
(i) Calculate the value of  $i_2$ , if the angle of deviation is  $43^\circ$ .  
(ii) What is the ray QS called? (ICSE 2023)

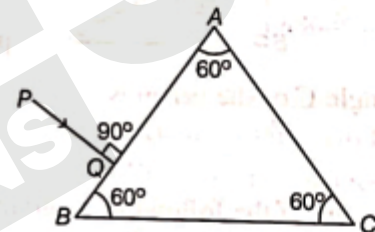


17. (i) A coin kept inside water [ $\mu = 4/3$ ] when viewed from air in a vertical direction appears to be raised by 3.0mm. Find the depth of the coin in water.  
(ii) How is the critical angle related to the refractive index of a medium? (ICSE 2023)

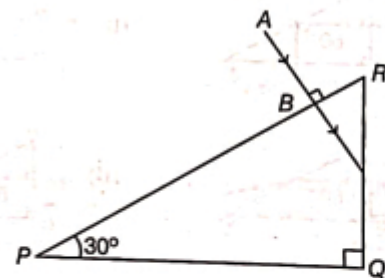
#### KEY idea

To obtain the shift, first calculate the apparent depth and then calculate the shift.

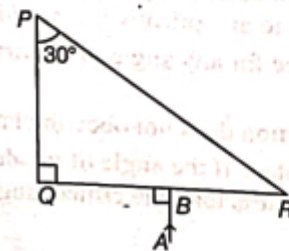
18. Copy the diagram given below and complete the path of the light ray PQ, as it emerges out of the prism by marking necessary angles. The critical angle of glass is  $42^\circ$ . (ICSE 2023)



19. Redraw and complete the path of the ray AB till it emerges out of the prism of critical angle  $42^\circ$ . (ICSE SQP 2023)

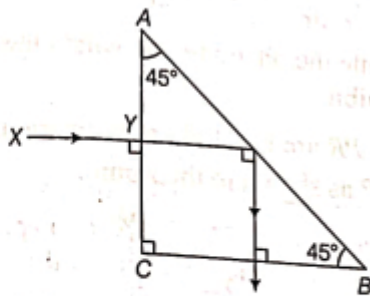


20. Complete the path of the ray AB through the glass prism in PQR till it emerges out of the prism. Given the critical angle of the glass as  $42^\circ$ . (ICSE 2020)

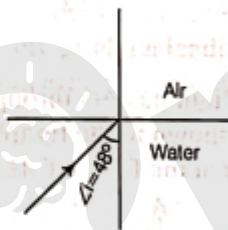




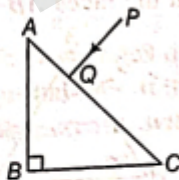
21. A ray of light  $XY$  passes through a right angled isosceles prism as shown below



- What is the angle through which the incident ray deviates and emerges out of the prism?
  - Name the instrument, where this action of prism is put into use.
  - Which prism's surface will behave as a mirror?
- (ICSE 2018)
22. Draw the diagram of a right angled isosceles prism which is used to make an inverted image erect.  
(ICSE 2018)
23. A ray of light travels from water to air as shown in the diagram given alongside



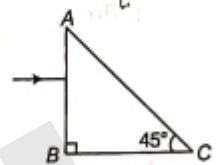
- Copy the diagram and complete the path of the ray. Given, the critical angle for water is  $48^\circ$ .
  - State the condition, so that total internal reflection occurs in the above diagram.
- (ICSE 2017)
24. A ray of light  $PQ$  is incident normally on the hypotenuse of a right angled prism  $ABC$  as shown in the diagram given alongside.



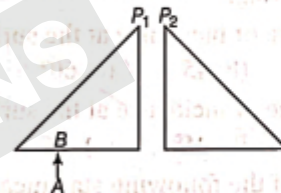
- Copy the diagram and complete the path of the ray  $PQ$  till it emerges from the prism.
  - What is the value of the angle of deviation of the ray?
  - Name an instrument, where this action of the prism is used.
- (ICSE 2012)

25. (i) Draw a labelled ray diagram to illustrate (a) critical angle (b) total internal reflection for a ray of light moving from one medium to another.  
(ii) Write a formula to express the relationship between refractive index of the denser medium with respect to rarer medium and its critical angle for that pair of media.  
(ICSE 2008)

26. The diagram given alongside shows a right angled prism with a ray of light incident on the side  $AB$ .  
(The critical angle for glass is  $42^\circ$ ).

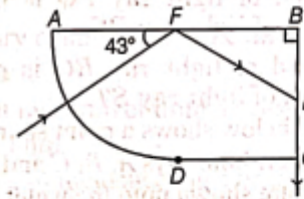


- Copy the diagram and complete the path of the ray of light in and out of the glass prism.
  - What is the value of the angle of deviation shown by the ray?
- (ICSE 2007)
27. (i) Two isosceles right angled prisms are arranged as shown in the figure. Copy the diagram and complete the path of the ray  $AB$  along which it passes through the prisms and comes out.  
(ii) Name the phenomenon being displayed by the path of the ray in the diagram.  
(ICSE 2002)



### 4 Marks Questions

28. A ray of light travelling from air into a glass material as shown below. Answer the questions that follow.  
(ICSE 2022 Sem-I)

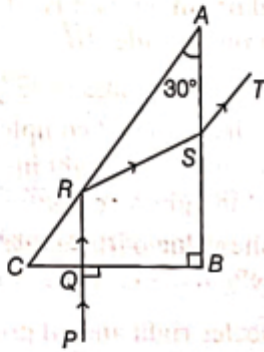


- The angle of incidence at the surface  $AB$  is  
(a)  $43^\circ$  (b)  $47^\circ$  (c)  $90^\circ$  (d)  $0^\circ$
- Select a correct statement from the following.
  - The speed of light at the curved surface  $AD$  does not change while entering the block.
  - The ray at the surface  $AD$  is not travelling along the radius of the curved part.
  - The ray at the surface  $AD$  is travelling along the radius of the curved part.
  - Light never refracts when it enters a curved surface.



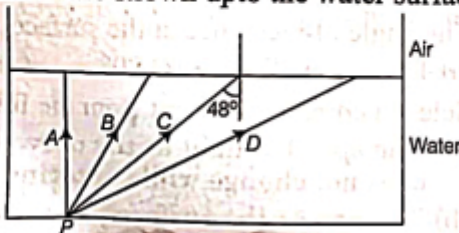
- (iii) The angle of incidence on the surface  $BC$  is  
(a)  $43^\circ$  (b)  $47^\circ$  (c)  $90^\circ$  (d)  $0^\circ$
- (iv) The critical angle of this material of glass is  
(a)  $47^\circ$  (b)  $43^\circ$  (c)  $42^\circ$  (d)  $45^\circ$

29. The diagram shows the path of light through a right-angled prism of critical angle  $42^\circ$ .  
Observe the diagram and answer the questions that follow. (ICSE SQP 2022 Sem-I)



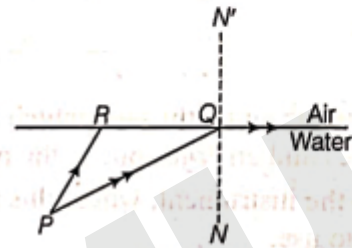
- (i) The phenomenon at the surface  $AC$  is  
(a) refraction  
(b) partial reflection  
(c) total internal reflection  
(d) scattering.
- (ii) The angle of incidence at the surface  $AC$  is  
(a)  $30^\circ$  (b)  $45^\circ$  (c)  $60^\circ$  (d)  $90^\circ$
- (iii) The angle of incidence at the surface  $AB$  is  
(a)  $30^\circ$  (b)  $45^\circ$  (c)  $60^\circ$  (d)  $90^\circ$
- (iv) Which of the following statement is wrong?  
(a) Speed of light ray  $PQ$  is equal to the speed of light ray  $ST$ .  
(b) Speed of light ray  $QR$  is equal to the speed of light ray  $RS$ .  
(c) Speed of light ray  $PQ$  is greater than the speed of light ray  $RS$ .  
(d) Speed of light ray  $RQ$  is greater than the speed of light ray  $ST$ .

30. The diagram below shows a point source  $P$  inside a water container. Four rays  $A, B, C$  and  $D$  starting from the source  $P$  are shown upto the water surface.



- (i) Show in the diagram, the path of these rays after striking the water surface. The critical angle for water-air surface is  $48^\circ$ .
- (ii) Name the phenomenon which the rays  $B$  and  $D$  exhibit. (ICSE 2017)

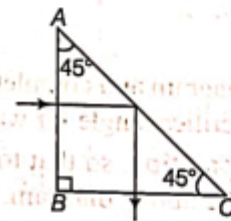
31.  $PQ$  and  $PR$  are two light rays emerging from the object  $P$  as shown in the figure.



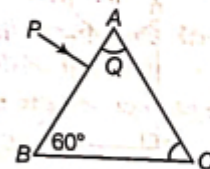
- (i) What is the special name given to the angle of incidence ( $\angle PQN$ ) of ray  $PQ$ ?
- (ii) Copy the ray diagram and complete it to show the position of the image of the object  $P$ , when seen obliquely from above.
- (iii) Name the phenomenon that occurs, if the angle of incidence  $\angle PQN$  is increased still further. (ICSE 2006)

32. (i) Define critical angle.

- (ii) A ray of light pass through a right angled prism as shown in the figure. State the angles of incidence at the faces of  $AC$  and  $BC$ . (ICSE 2004)



- 33. (i) In the given diagram, a ray of light  $PQ$  is incident normally on one face  $AB$  of an equilateral glass prism. What are the angles of incidence at the faces  $AB$  and  $AC$ ?



- (ii) Complete the ray diagram showing its emergence into air after passing through the prism. (ICSE 2002)