

Refraction

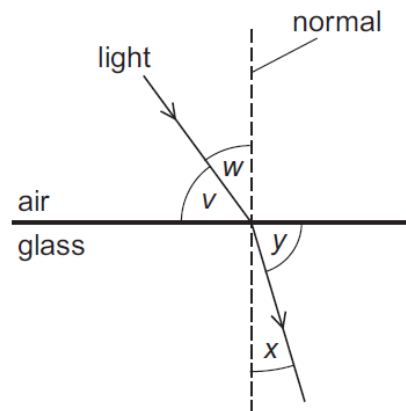
MCQ

Refractive Index and Snell's Law

- 1 The speed of light in crown glass is $2.0 \times 10^8 \text{ m s}^{-1}$. Given that the speed of light in vacuum is $3.0 \times 10^8 \text{ m s}^{-1}$, calculate the refractive index of crown glass.

- A 0.67
- B 1.0
- C 1.5
- D 5.0

- 2 Four angles v , w , x and y are shown.



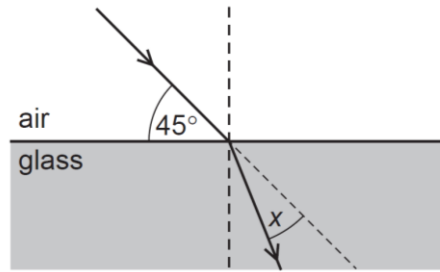
Which formula is used to calculate the refractive index n of the glass?

- A $n = \frac{\sin v}{\sin y}$ B $n = \frac{\sin v}{\sin x}$ C $n = \frac{\sin w}{\sin y}$ D $n = \frac{\sin w}{\sin x}$

- 3 A ray of light travels from air into glass. The refractive index of the glass is 1.5. Which of the following pairs could be values of the angle of incidence and the angle of refraction?

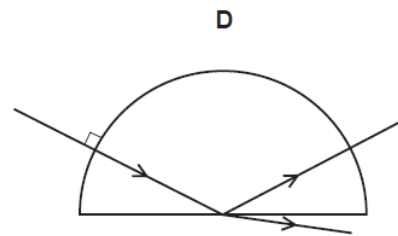
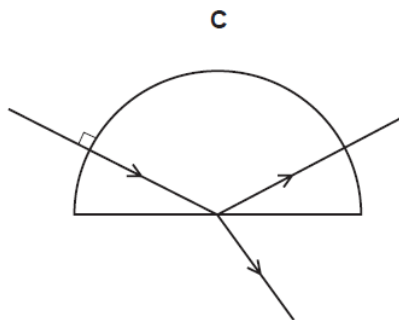
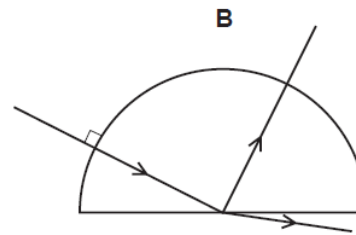
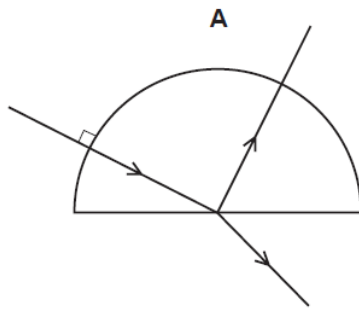
	<i>angle of incidence/°</i>	<i>angle of refraction/°</i>
A	21.5	20.0
B	40.0	60.0
C	60.0	35.3
D	80.0	53.3

- 4 A ray of light is incident on the surface of a glass block, as shown in the diagram below.



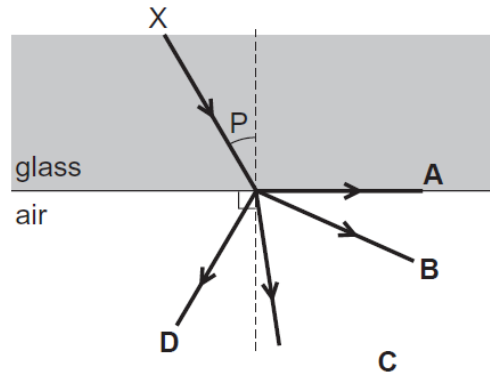
The refractive index of the glass is 1.5. The light ray changes direction when entering the glass. What is the angle x through which the ray moves?

- A 30° B 28° C 17° D 15°
- 5 A ray of red light enters a semi-circular glass block normal to the curved surface. Which diagram shows the partial reflection and refraction of the ray?

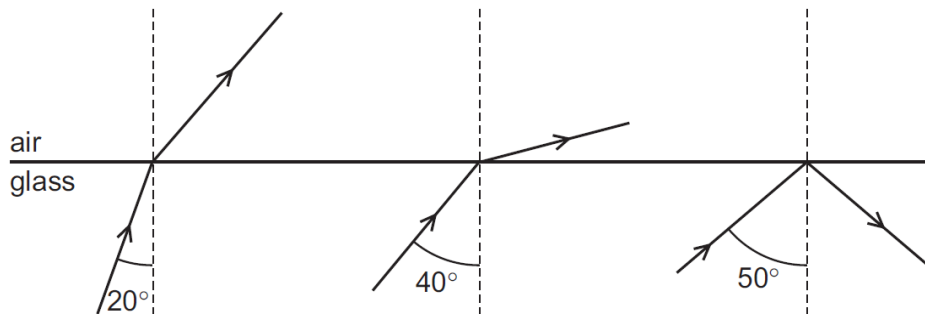


Critical Angle and TIR

- 6 The diagram shows a ray of light travelling from X. Angle P is less than the critical angle. Which direction does the ray continue?



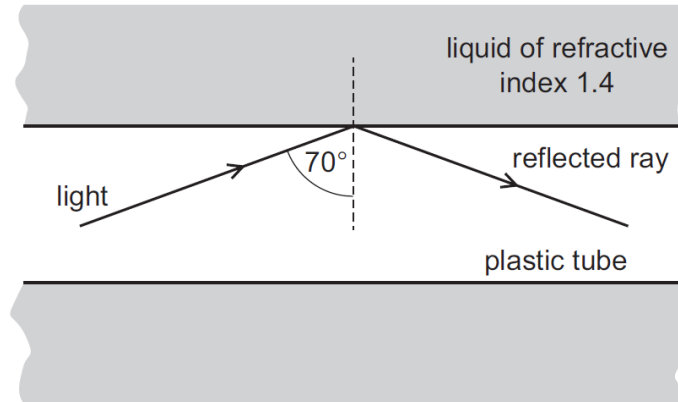
- 7 Three rays of light are incident on the boundary between a glass block and air. The angles of incidence are different.



What is a possible critical angle for light in the glass?

- A 15° B 30° C 45° D 60°

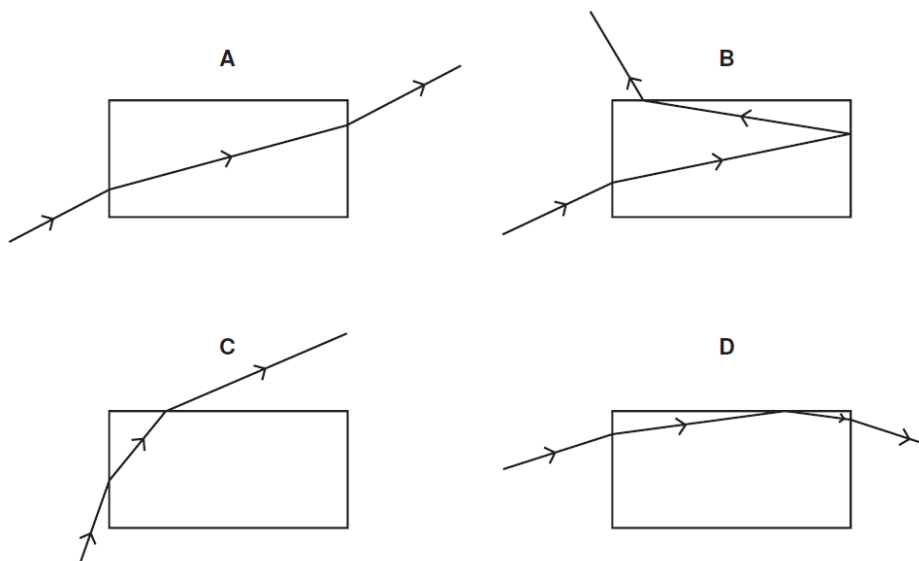
- 8 A plastic tube is immersed in a liquid of refractive index 1.4. Light travelling in the plastic tube strikes the inside surface at an angle of incidence of 70° . The light undergoes total internal reflection.



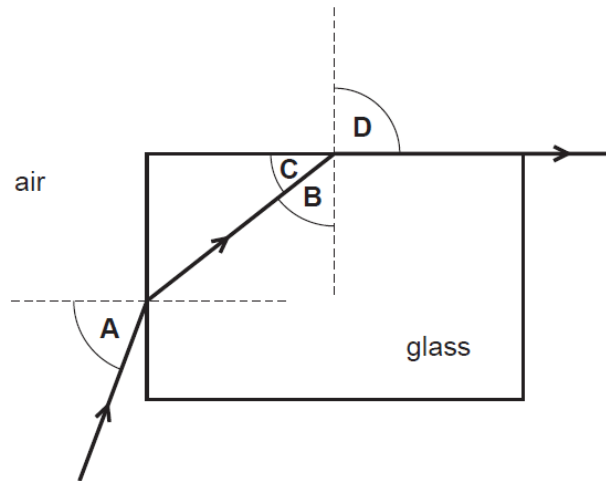
What describes the values of the critical angle in the plastic and the refractive index of the plastic?

	<i>critical angle in plastic</i>	<i>refractive index of plastic</i>
A	greater than 70°	greater than 1.4
B	greater than 70°	less than 1.4
C	less than 70°	greater than 1.4
D	less than 70°	less than 1.4

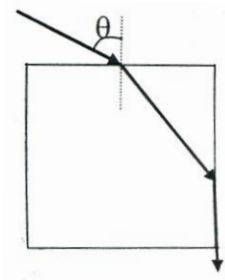
- 9 A ray of light is incident on one side of a rectangular glass block. Its path is plotted through the block and out through another side. Which path is not possible?



- 10 Light travels through a glass block as shown. Which angle is the critical angle for light in the glass?



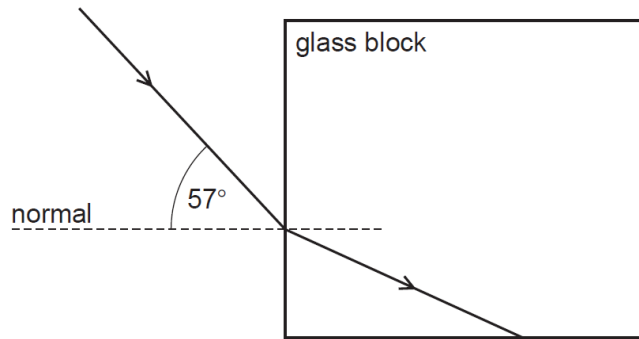
- 11 The diagram shows a ray of monochromatic light incident from air onto a rectangular glass block with an angle of incidence θ .



It emerges into air with an angle of refraction of 90° as shown. If the refractive index of the glass block is 1.40, what is the value of θ ?

- A 11.6° B 44.4° C 45.6° D 78.4°

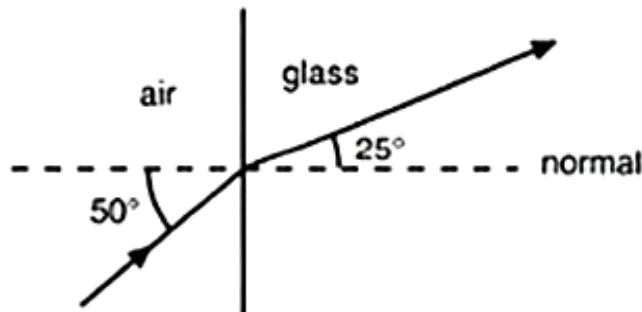
- 12 Light passes from air into a glass block of refractive index 1.5, as shown.



What is the angle of refraction in the glass and what is the critical angle?

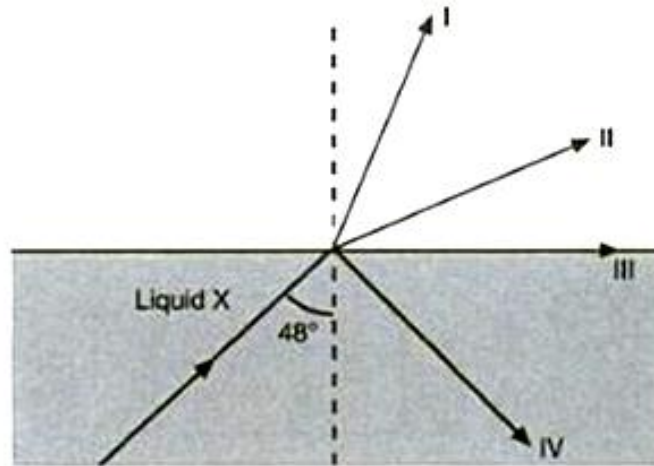
	<i>angle of refraction/°</i>	<i>critical angle/°</i>
A	34°	42°
B	34°	60°
C	38°	42°
D	38°	60°

- 13 A ray of red light travels from air to glass as shown. What is the critical angle for the glass?

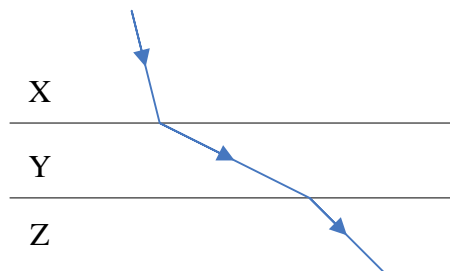


- A** 33.5° **B** 41.1° **C** 45.0° **D** 45.2°

- 14 A ray of light passing from liquid X into air makes an angle of incidence of 48° as shown in the following diagram.



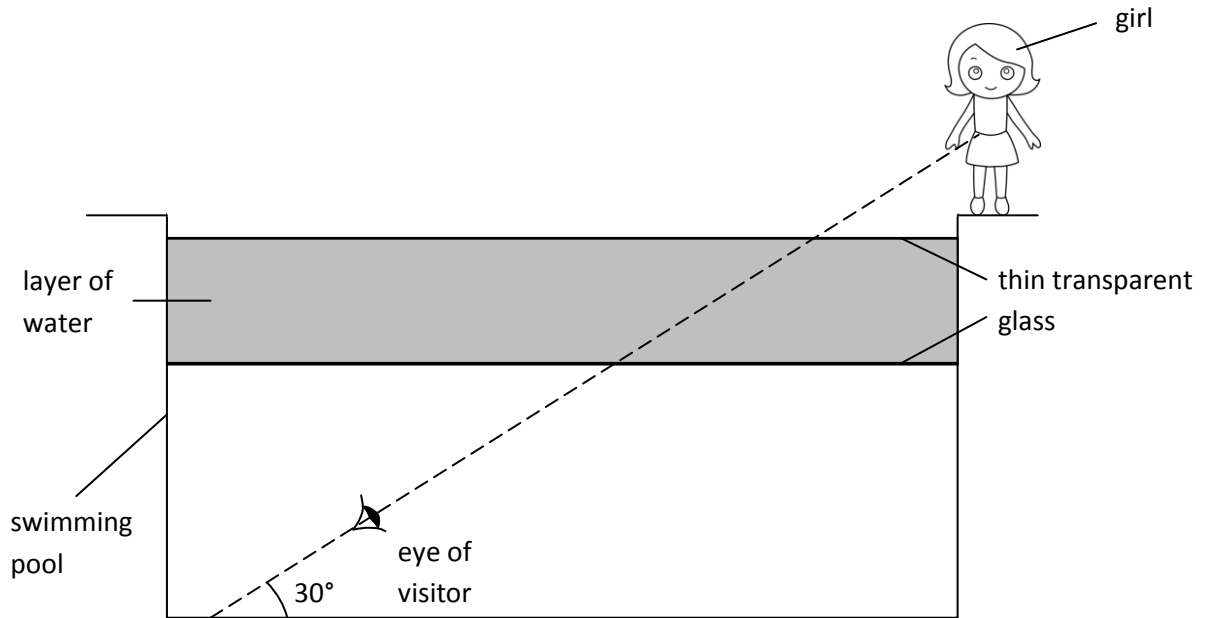
- If the refractive index of the liquid is 1.40, which is the most probable refracted/reflected ray of light?
- A I B II C III D IV
- 15 A ray of light passes through materials X, Y and Z with refractive indices n_x , n_y and n_z respectively.



- Which of the following statements about the refractive indices is correct?
- A $n_z > n_y > n_x$
 B $n_y > n_x$ and $n_y > n_z$
 C $n_x > n_z > n_y$
 D $n_z > n_x > n_y$

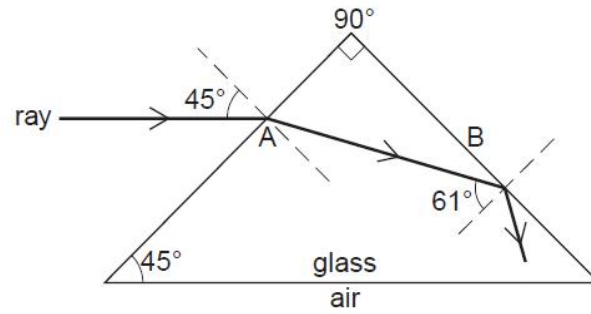
Structured Questions

- 16** In 1999, artist Leandro Erlich created an art installation titled "Swimming Pool", which allows visitors to look into a pool supposedly filled with water to find other fully-clothed visitors walking around the bottom of the pool. The illusion of being underwater is created by trapping a layer of water between two sheets of thin transparent glass as seen below.

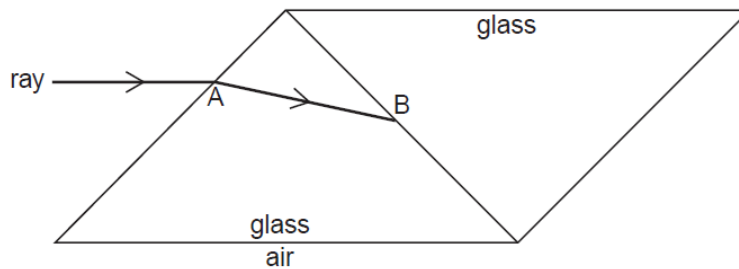


- (a)** State the laws of refraction.
- (b)** A visitor looks up from the bottom of the swimming pool with an angle of elevation of 30° and sees a girl. Sketch the path of a light ray from the girl to the eye of the visitor on the figure above.
- (c)** **(i)** State the angle of incidence when the light ray strikes the top of the layer of water.
(ii) Hence, calculate the angle of refraction. Take the refractive index of water to be 1.33.
- (d)** If the water used in the art installation is replaced with a clear liquid of a lower refractive index, describe how the image of the girl seen by the visitor changes. Explain your answer clearly.

- 17 A ray of monochromatic light passes through the glass prism as shown below.

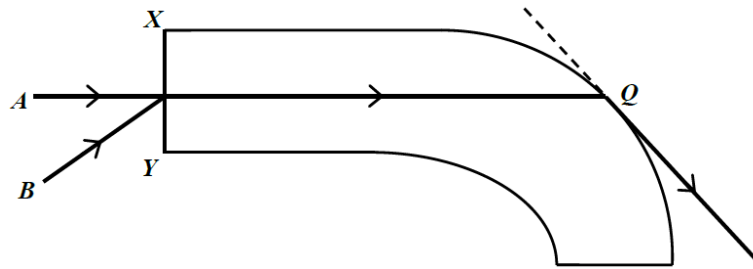


- (a) Calculate the angle of refraction at A.
- (b) Calculate the refractive index of the glass.
- (c) An identical prism is stuck to the first prism using a transparent adhesive with the same refractive index as the glass. This is shown below.



On the figure above, draw the path of the ray after it has reached B and until it has passed into the air again.

- 18** The figure below shows a section of an optical fibre which has a refractive index of 1.45. Two rays, A and B, are incident on surface XY of the fibre. Ray A emerges into the air along the tangent of the optical fibre at point Q.



- (a) Explain why there is no change in the direction of light when ray A enters the optical fibre.
- (b) State two conditions for ray A to emerge into the air along the tangent of the optical fibre at point Q.
- (c) Calculate the critical angle of the optical fibre.
- (d) Determine the value of the critical angle measured in (c) when the fibre is immersed in water. Take the refractive index of water to be 1.33.
- (e) Ray B meets ray A again at point Q. On the diagram, continue the path of ray B in the optical fibre until it reaches point Q.

Answers

MCQ

Refractive Index and Snell's Law

CDCCD

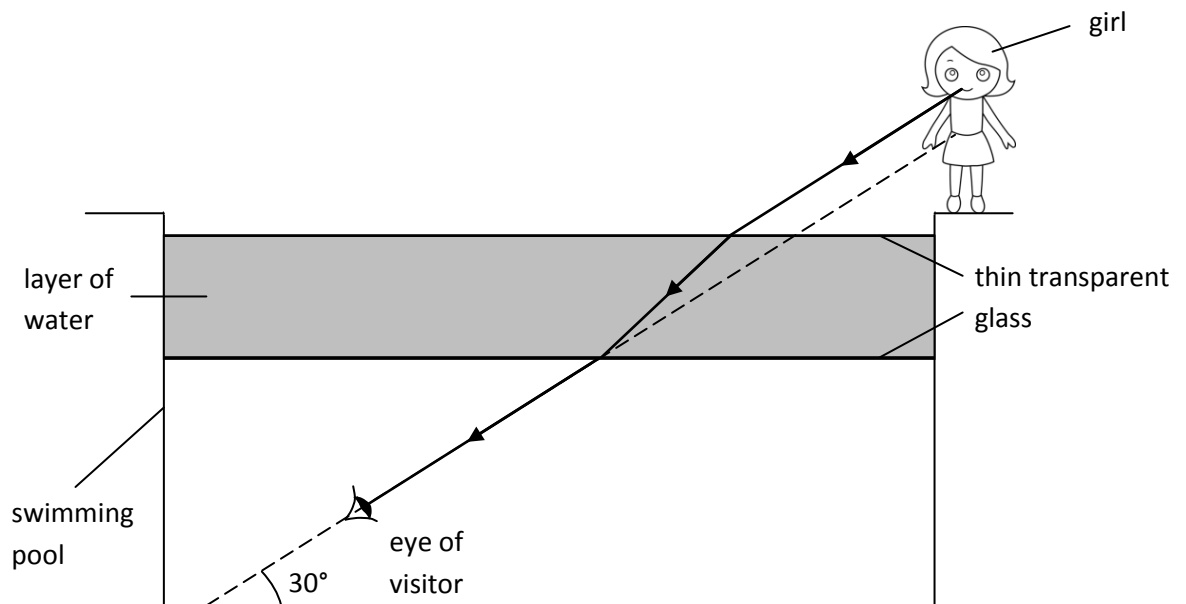
Critical Angle and TIR

BCCBB DAADC

Structured Questions

- 16 (a) 1. the incident ray, refracted ray, and the normal at the point of incidence all lie on the same plane
2. the ratio of the sine of the angle of incident to the sine of the angle of refraction ($\sin i/\sin r$) is a constant

(b)



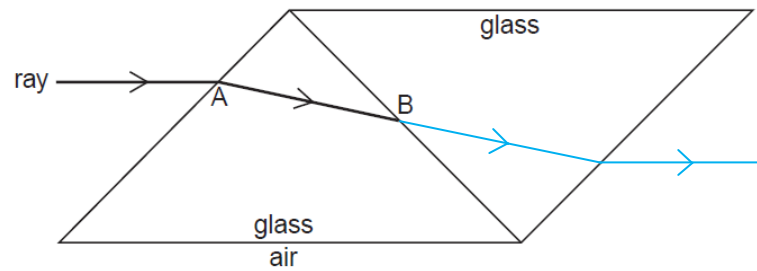
- (c) (i) 60°
(ii) 40.6°

- (d) The image will shift upwards/appears higher up as a liquid with lower optical density (or liquid with a lower refractive index) causes a smaller change in direction of the incident ray.

17 (a) 29°

(b) 1.46

(c)



18 (a) Ray A is perpendicular to XY and hence, the angle of incidence is zero.

- (b) 1. the angle of incidence is equal to the critical angle
2. the refractive index of the optical fibre is greater than that of air

(c) 43.6°

(d) 66.5°

(e)

