

Questions

Q1.

A ray of light travels through glass, towards a boundary between glass and air. The critical angle for this boundary is 42° .

Which row of the table is correct?

	Angle of incidence	What happens at the boundary?
☐ A	40°	All of the light is refracted
☐ B	40°	All of the light is reflected
☐ C	45°	All of the light is refracted
☐ D	45°	All of the light is reflected

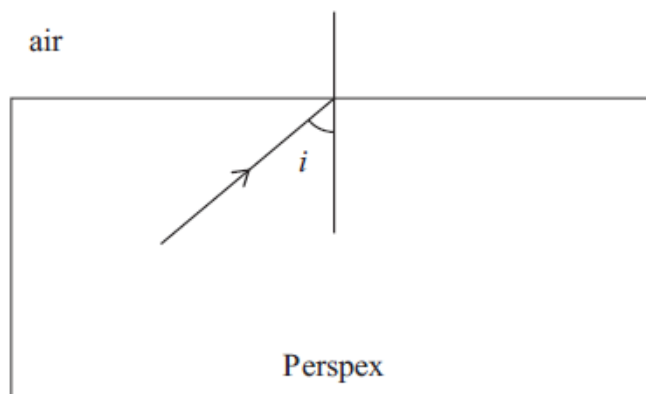
(Total for question = 1 mark)

Q2.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

A ray of light is incident on the boundary between Perspex and air, as shown.

The angle of incidence i is greater than the critical angle for the Perspex-air boundary.



Which of the following statements is correct for the Perspex-air boundary?

- ☐ **A** All the light is refracted.
- ☐ **B** All the light is transmitted.
- ☐ **C** All the light is reflected.
- ☐ **D** Some light is reflected and some light is refracted.

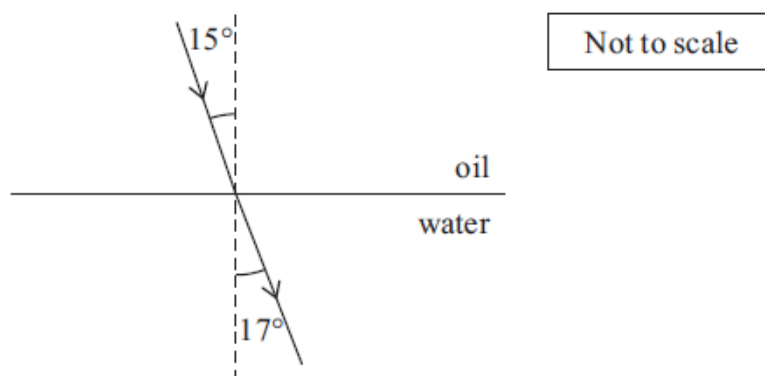
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Q3.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

The diagram shows a ray of light incident at a boundary between oil and water.

The refractive index of water is 1.33



Which of the following expressions gives the refractive index of the oil?

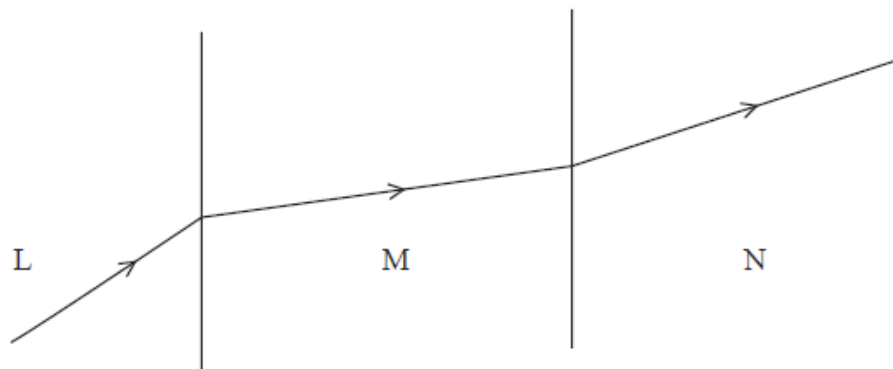
- ☐ **A** $\frac{\sin 17^\circ}{1.33 \sin 15^\circ}$
- ☐ **B** $\frac{1.33 \sin 17^\circ}{\sin 15^\circ}$
- ☐ **C** $\frac{\sin 15^\circ}{1.33 \sin 17^\circ}$
- ☐ **D** $\frac{1.33 \sin 15^\circ}{\sin 17^\circ}$

(Total for question = 1 mark)

Q4.

Select one answer from A to D and put a cross ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The diagram shows refraction of a ray of light as it passes through three transparent substances, L, M and N. The speeds of light in the three substances are v_L , v_M and v_N , respectively.



Which of the following could result in a ray of light undergoing total internal reflection?

- ☐ **A** light travelling from L to M
- ☐ **B** light travelling from L to N
- ☐ **C** light travelling from M to L
- ☐ **D** light travelling from N to M

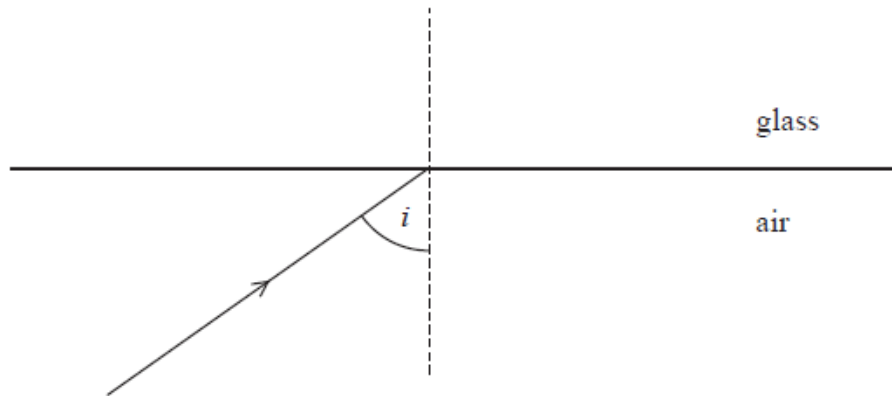
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Q5.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

A ray of light approaches a boundary between air and glass, as shown.

The angle of incidence is i .



Which of the following statements about total internal reflection (TIR) is correct for the ray of light at this boundary?

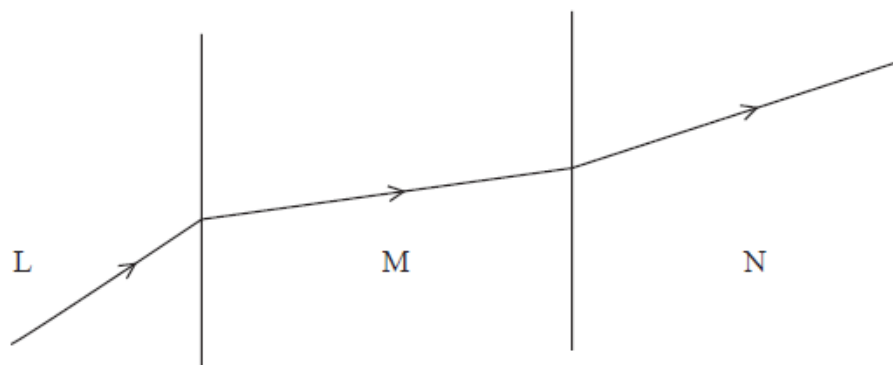
- ☐ **A** TIR cannot take place.
- ☐ **B** TIR takes place if i is equal to the critical angle.
- ☐ **C** TIR takes place if i is greater than the critical angle.
- ☐ **D** TIR takes place if i is less than the critical angle.

(Total for question = 1 mark)

Q6.

Select one answer from A to D and put a cross in the box ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The diagram shows refraction of a ray of light as it passes through three transparent substances, L, M and N. The speeds of light in the three substances are v_L , v_M and v_N , respectively.



Which of the following shows the relationship between v_L , v_M and v_N ?

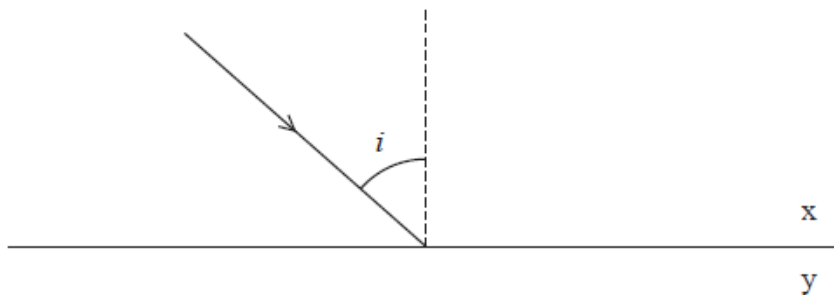
- ☐ **A** $v_L > v_M > v_N$
- ☐ **B** $v_L > v_N > v_M$
- ☐ **C** $v_N > v_M > v_L$
- ☐ **D** $v_M > v_N > v_L$

(Total for question = 1 mark)

Q7.

Answer the question with a cross in the box you think is correct (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

A ray of light is incident on the boundary between two materials, x and y, as shown. The refractive index value for material x is n_x and for material y is n_y .



Which row of the table gives the conditions required for total internal reflection to take place at this boundary?

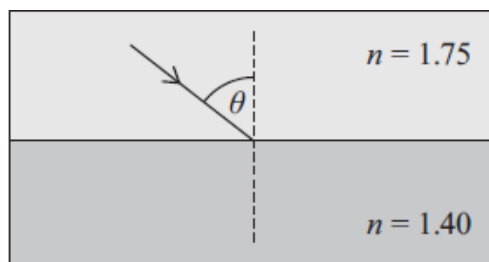
	Condition 1	Condition 2
☐ A	$i > \text{critical angle}$	$n_x > n_y$
☐ B	$i > \text{critical angle}$	$n_x < n_y$
☐ C	$i < \text{critical angle}$	$n_x > n_y$
☐ D	$i < \text{critical angle}$	$n_x < n_y$

(Total for question = 1 mark)

Q8.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

A ray of light is travelling through a material of refractive index 1.75. The ray is incident at the boundary with a material of refractive index 1.40, as shown.



Not to scale

Which of the following expressions gives the condition for total internal reflection?

☐ A $\theta > \sin^{-1}\left(\frac{1.40}{1.75}\right)$

☐ B $\theta > \sin^{-1}\left(\frac{1.75}{1.40}\right)$

☐ C $\theta < \sin^{-1}\left(\frac{1.40}{1.75}\right)$

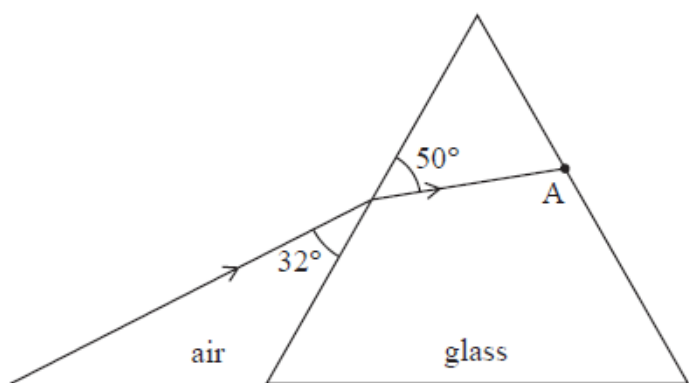
☐ D $\theta < \sin^{-1}\left(\frac{1.75}{1.40}\right)$

(Total for question = 1 mark)

Q9.

In an experiment to determine the refractive index of glass, a student directed a ray of light towards a glass prism.

The ray of light is shown before and after entering the prism.



(a) (i) Determine the refractive index of the glass.

(3)

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Refractive index of glass =

(ii) Draw, on the diagram, the ray of light as it emerges from the prism at A.

No further calculations are required.

(1)

(b) A different prism is made of glass with a refractive index of 1.63

Calculate the speed of light in this glass.

(2)

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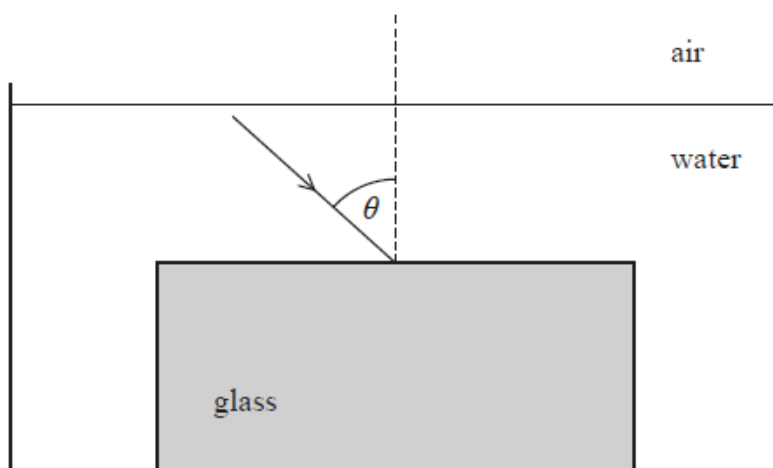
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Speed of light in glass =

(Total for question = 6 marks)

Q10.

A block of glass is submerged in a container of water. A ray of light travelling in the water is directed towards the glass surface as shown.



refractive index of water = 1.33

refractive index of glass = 1.52

(a) Calculate the angle of refraction within the glass block when $\theta = 43.0^\circ$.

(2)

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Angle of refraction =

(b) Determine the critical angle for light at a glass-water boundary.

(2)

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Critical angle =

(Total for question = 4 marks)

Q11.

The refractive index of water is 1.33

(a) Calculate the speed of light in water.

(2)

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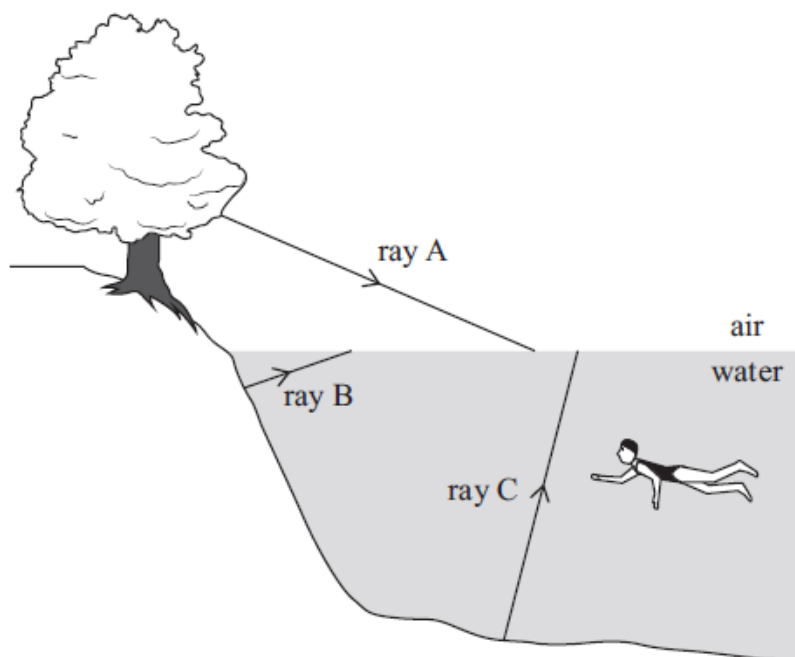
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Speed of light in water =

*(b) A person is swimming underwater in a lake. The person looks up towards the surface.

Three rays of light, A, B and C, are incident on the surface of the water, as shown.



Each ray changes direction at the surface of the water.

Light from rays A and B reaches the person's eyes.

Most of the light from ray C does **not** reach the person's eyes.

Explain the paths of rays A, B and C after each ray changes direction at the surface of the water.

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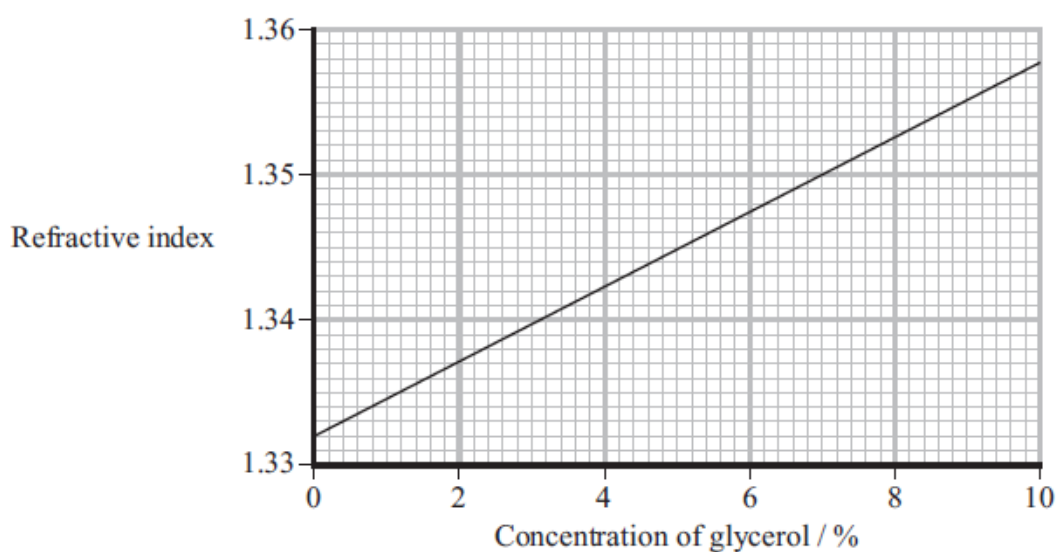
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(Total for question = 8 marks)

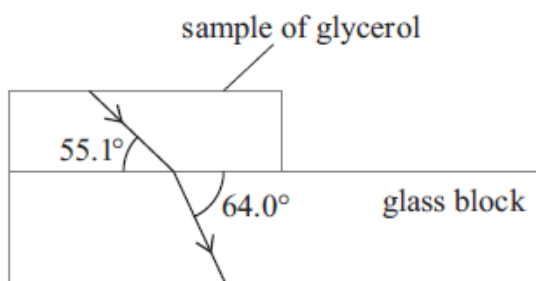
Q12.

A device called a refractometer can be used to determine the concentration of a solution of glycerol.

The graph shows the refractive index for different concentrations of glycerol.



(a) In a refractometer, a ray of light is shone through a sample of glycerol and refracts at the surface of a glass block, as shown.



The refractive index of the glass block is 1.75

(i) Determine the speed of light in the glass block.

(2)

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Speed of light =

(ii) The table shows the concentration of different samples of glycerol.

Sample	Concentration / %
1	1.40
2	3.20
3	4.80

Deduce which sample is being tested in the refractometer.

(4)

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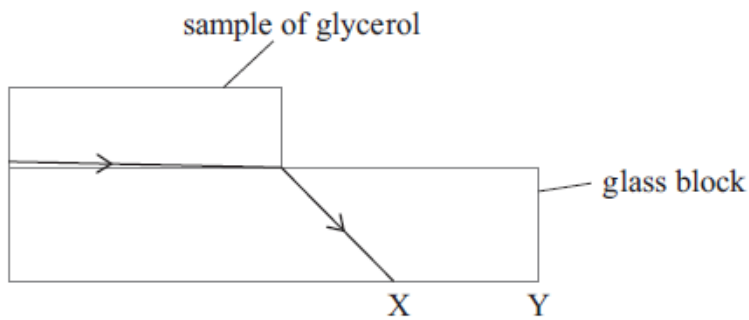
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(b) Light rays can be directed through the sample of glycerol at different angles of incidence. One ray of light is shown.



Explain why it is **not** possible for any light from the glycerol to reach the region between X and Y.

(2)

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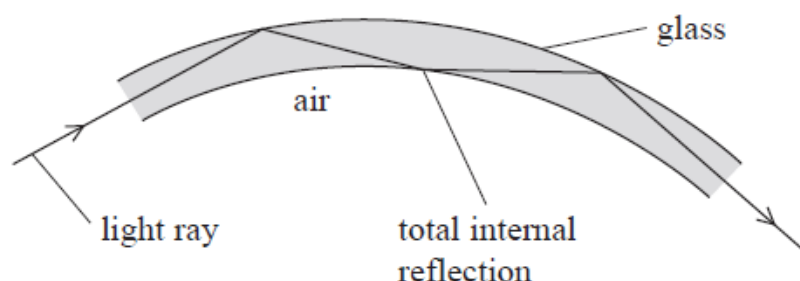
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(Total for question = 8 marks)

Q13.

An endoscope is a medical device that can be used to see inside the digestive system. The endoscope contains bundles of very fine glass fibres. Light is directed into the fibres to illuminate the part of the digestive system being investigated.

Light travels along the glass fibres by total internal reflection.



(a) State the conditions required for total internal reflection to occur.

(2)

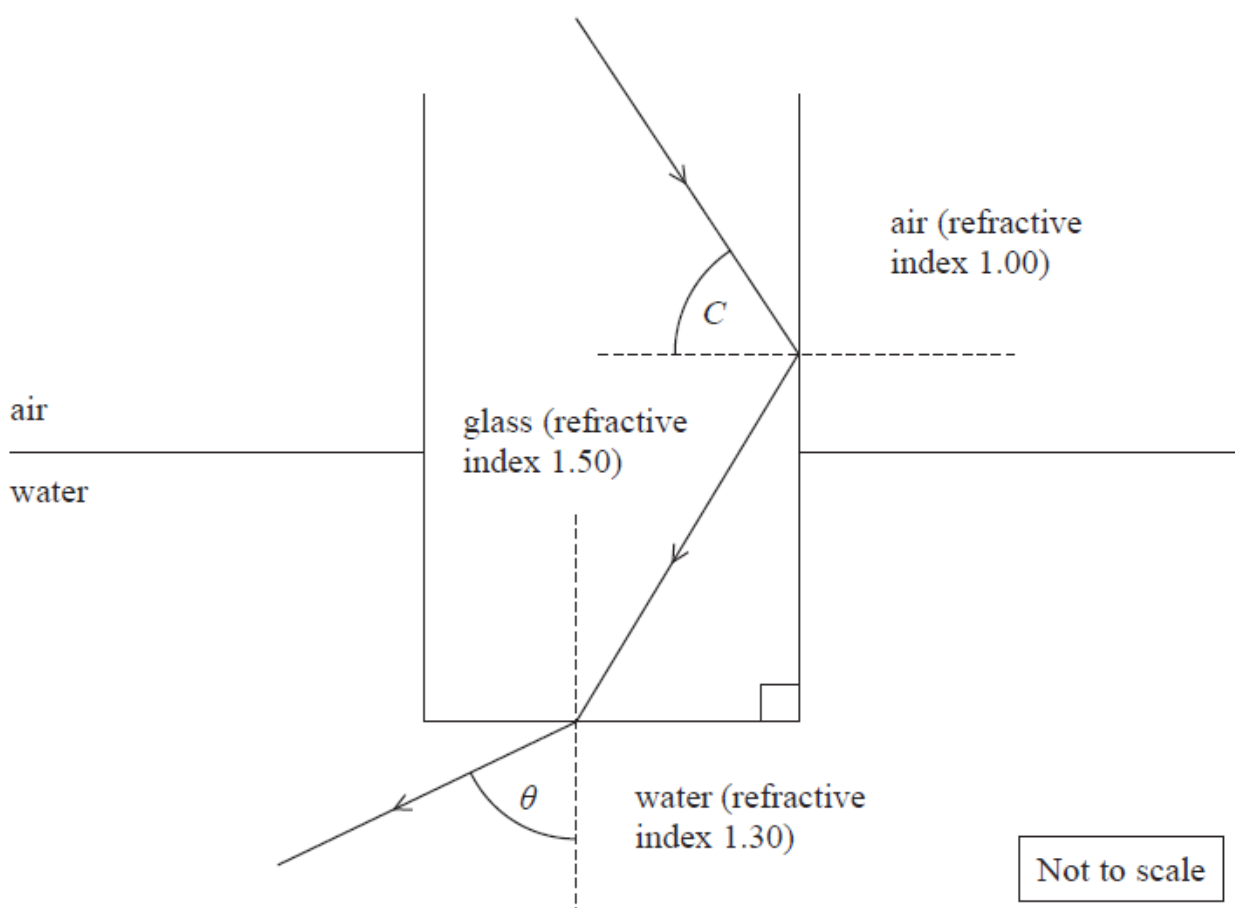
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(b) A ray of light is incident on the end of a glass fibre and refracts as it enters the glass. Explain why the light refracts as it enters the glass.

(2)

(c) The diagram shows a ray of light being totally internally reflected at one side of a glass fibre and then refracting as it leaves the end of the fibre. The angle of incidence at the boundary between the glass fibre and air is equal to the critical angle C for the glass-air interface. The ray enters water as it leaves the glass fibre.



Determine the angle θ between the emerging ray and the normal.

(4)

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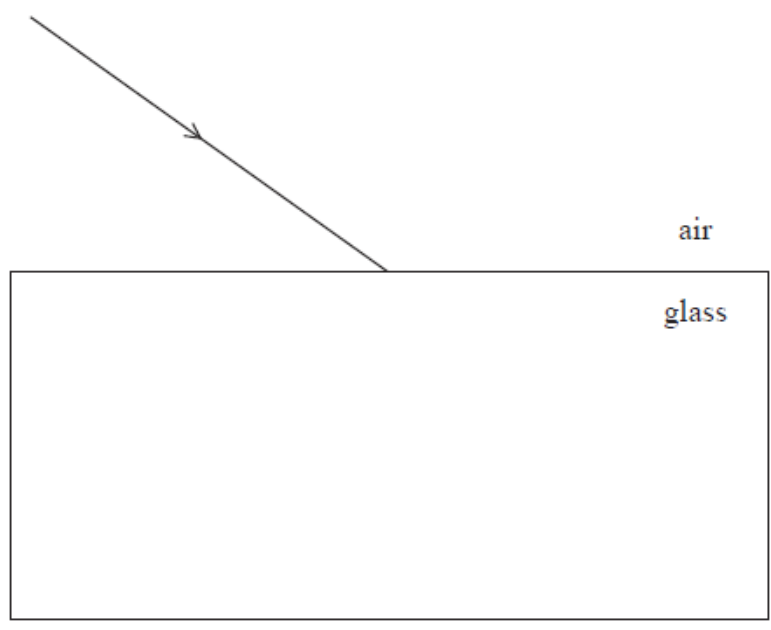
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$\theta =$

(Total for question = 8 marks)

Q14.

The diagram shows a ray of light incident on a glass block.



(a) Complete the diagram to show the path of the ray as it enters the block. Use the space below for any calculations.

refractive index of glass = 1.58

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(b) The speed of light in a different type of glass is $1.96 \times 10^8 \text{ m s}^{-1}$.

Calculate the value of the critical angle at a boundary between this type of glass and air.

(3)

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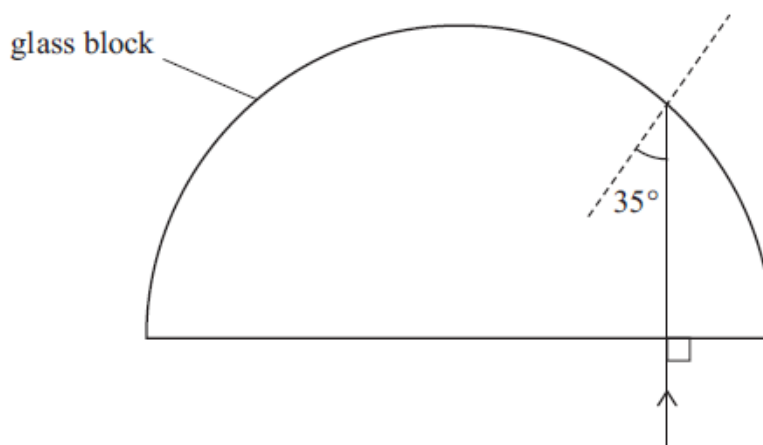
Critical angle =

(Total for question = 8 marks)

Q15.

A student used a semicircular glass block to investigate the refraction of light.

He directed a ray of light onto the glass block, as shown.



(a) State why the ray of light does not refract as it enters the glass block.

(1)

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(b) The glass has a refractive index of 1.5

(i) The ray of light is refracted at the curved surface of the block.

Calculate the angle of refraction.

(2)

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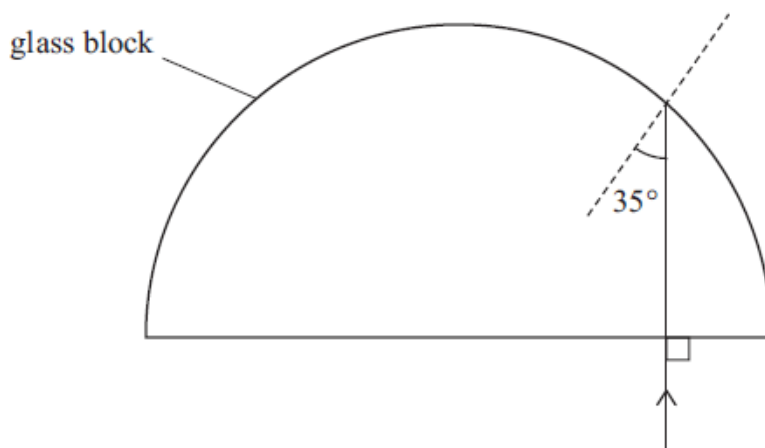
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Angle of refraction =

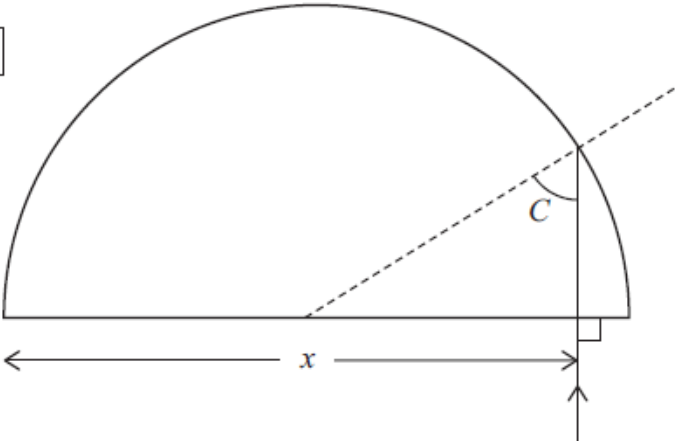
(ii) Complete the diagram to show the path of the ray of light as it leaves the glass block.

(1)



(c) The student moved the glass block so that the ray of light was incident on the curved surface at the critical angle C , as shown below.

Not to scale



Determine the distance x .

refractive index of glass = 1.5
radius of glass block = 45 mm

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Distance x =

(Total for question = 8 marks)

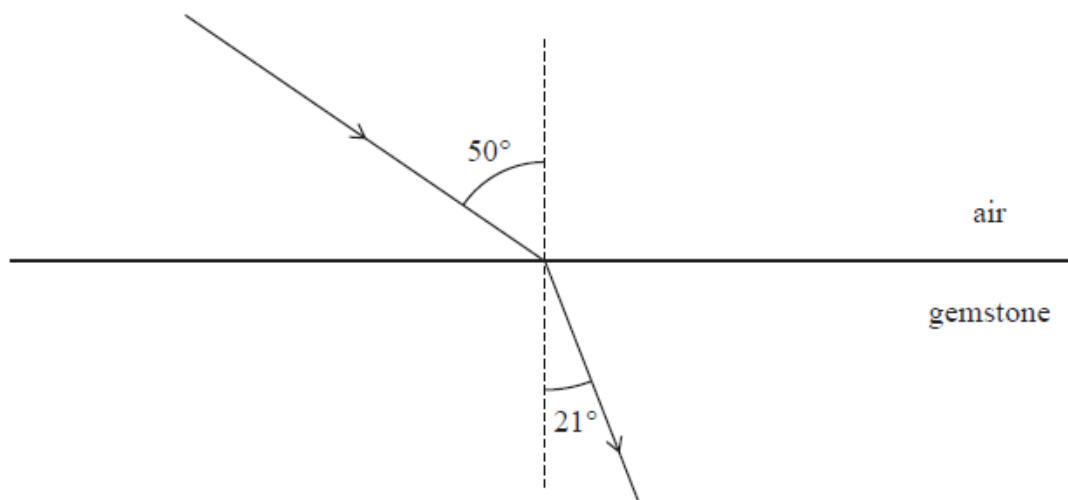
Q16.

Diamonds, cubic zirconia and silicon carbide can be used as gemstones in jewellery.

The speed of light in these materials is shown in the table.

	diamond	cubic zirconia	silicon carbide
speed of light / m s^{-1}	1.24×10^8	1.39×10^8	1.15×10^8

(a) In order to identify the material used, a ray of light is directed towards a boundary between air and the gemstone.



Deduce the material used for the gemstone.

(3)

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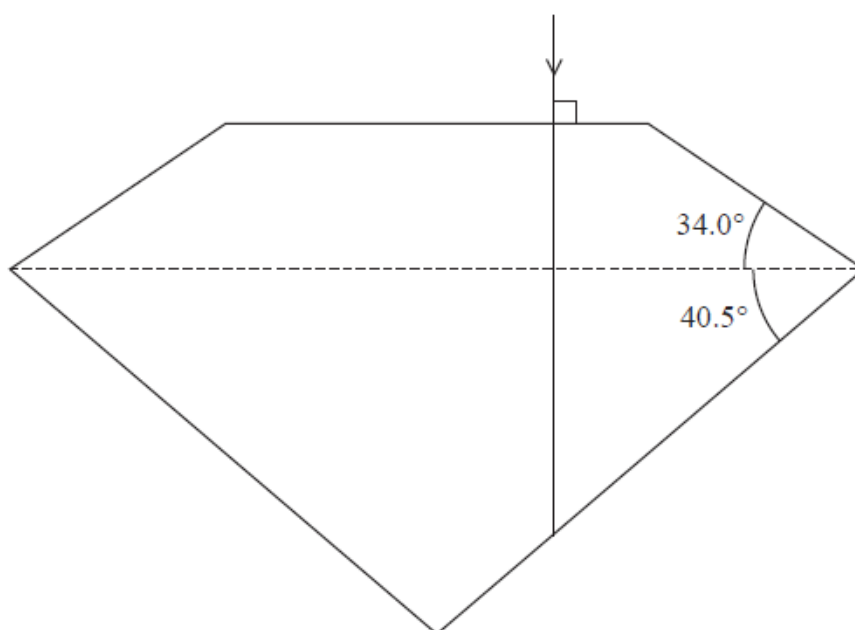
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(b) Diamonds are cut into different shapes so that they 'sparkle' when light shines on them.

The diagram shows a ray of light entering a diamond and incident on a boundary between diamond and air.



(i) Add to the diagram to show the path of the ray of light as it leaves this boundary. Your answer should include a calculation. (4)

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(ii) Explain what would happen to the ray at this boundary if the material used was silicon carbide instead of diamond. (2)

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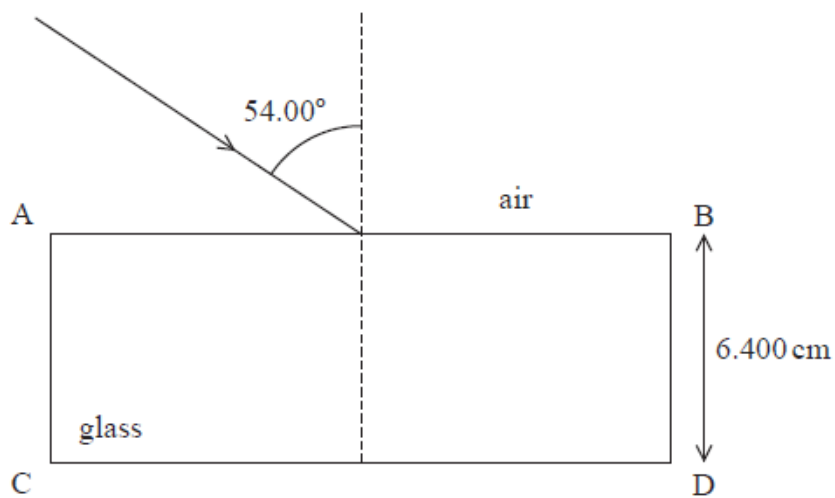
(Total for question = 9 marks)

Q17.

The refractive index of glass varies with the colour of light.

refractive index of glass for red light = 1.513
refractive index of glass for violet light = 1.532

(a) A ray of white light is incident on side AB of a rectangular glass block, as shown.



The red light and violet light from the incident ray arrive at slightly different points on side CD. Determine the distance between these points.

(5)

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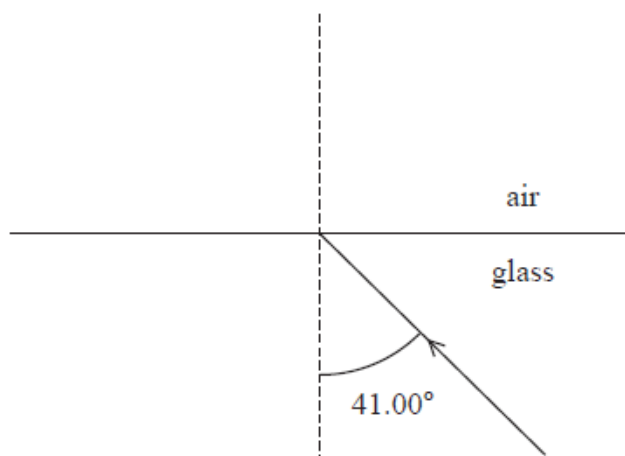
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Distance between points =

(b) White light is incident on a boundary between glass and air, as shown.



Explain what happens to the red light and the violet light when meeting the boundary. Your answer should include calculations.

(4)

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(Total for question = 9 marks)

Q18.

The speed of sound in sea water varies with depth as shown in diagram A.

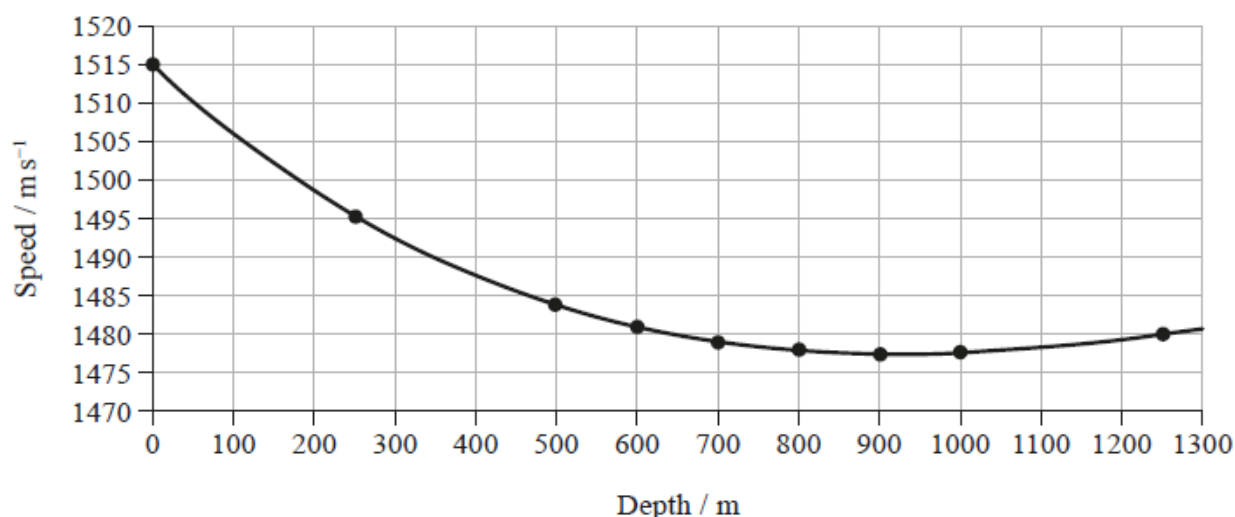


Diagram A

Sound produced at a depth of 900 m initially travels towards the water surface. As the sound approaches a depth of 700 m it changes direction and follows the path shown to the point P in diagram B.

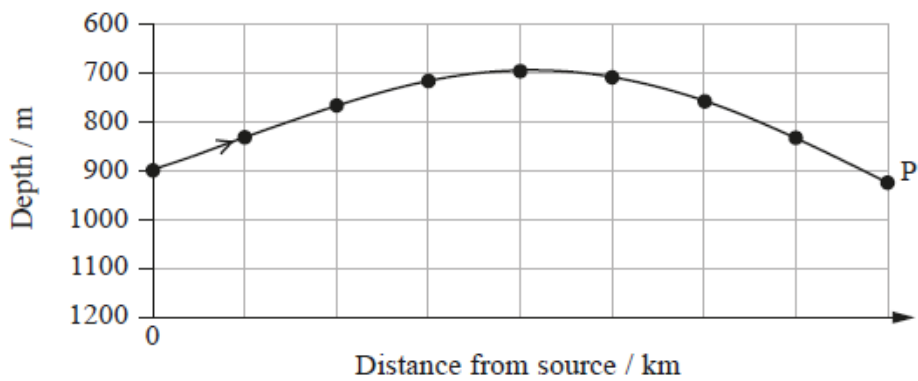


Diagram B

(a) Explain why the sound follows the path shown in diagram B.

Your answer should refer to refraction and diagram A.

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(b) Sound that travels in a straight line from the source to point P takes longer to arrive than sound that travels along the path shown in diagram B.

Suggest why.

(2)

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(c) Suggest two factors that might cause the speed of sound to vary with the depth of the sea.

(2)

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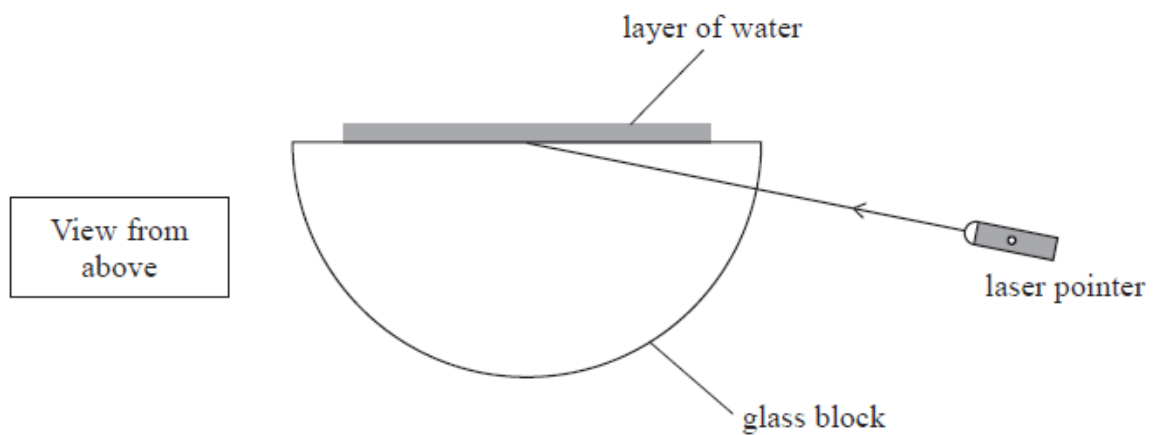
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(Total for question = 9 marks)

Q19.

A ray of light from a laser pointer is directed into a semi-circular glass block, as shown. There is a layer of water along the vertical flat side of the glass block.



(a) Explain why the ray of light does not change direction when entering the glass block.
Your answer should refer to wavefronts.

(4)

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(b) Show that the critical angle between glass and water is about 60° .

refractive index of glass = 1.51

refractive index of water = 1.33

(3)

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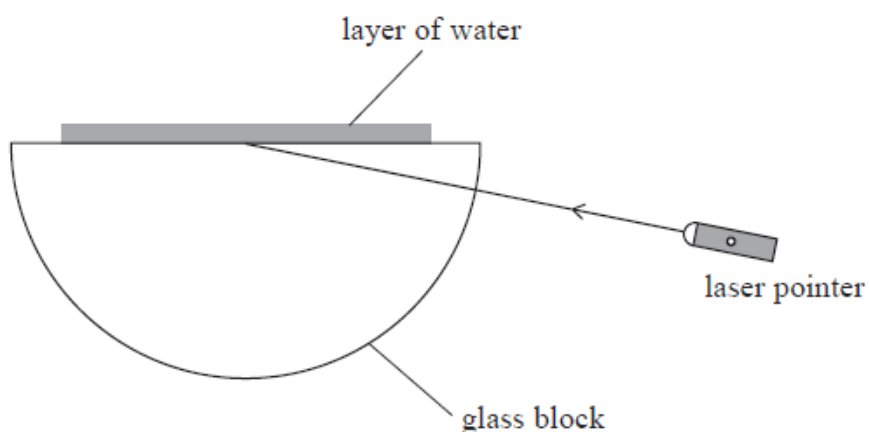
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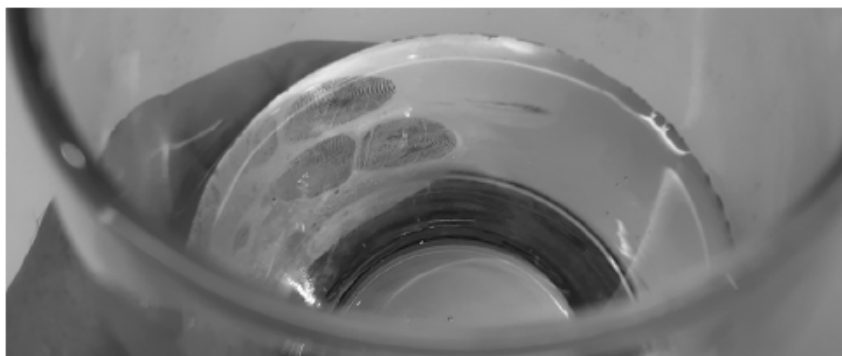
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(c) Complete the diagram to show the path of the ray of light after meeting the boundary between the glass and water.

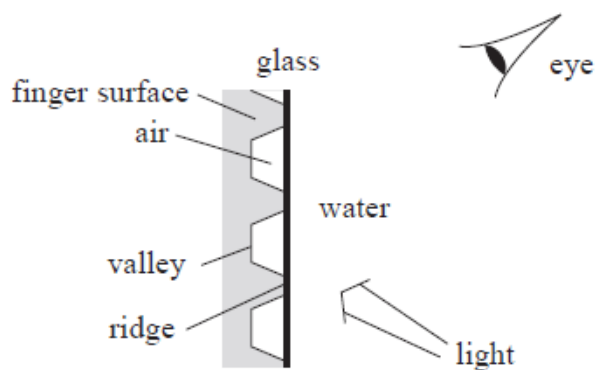
(3)



(d) The photograph shows a hand holding a glass beaker containing water.



Fingerprints are a series of ridges and valleys on the surface of fingers. The valleys trap air when the finger presses against the glass as shown in the diagram below.



Light in the water is incident upon the boundary between the glass and the air.

The critical angle between glass and air is about 40° . Skin has a similar value of refractive index to glass.

Explain why the fingerprints are seen as light and dark regions.

(4)

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(Total for question = 14 marks)