Questions

Q1.

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 filament lamp is a source of unpolarised light.

A polarising filter is placed between a filament lamp and an observer. The filter is rotated in the plane perpendicular to the direction of travel of the light.

Which of the following is observed as the filter is rotated through an angle of 90°?

☒ **A** The light intensity changes from maximum to minimum.

☒ **B** The light intensity changes from minimum to maximum.

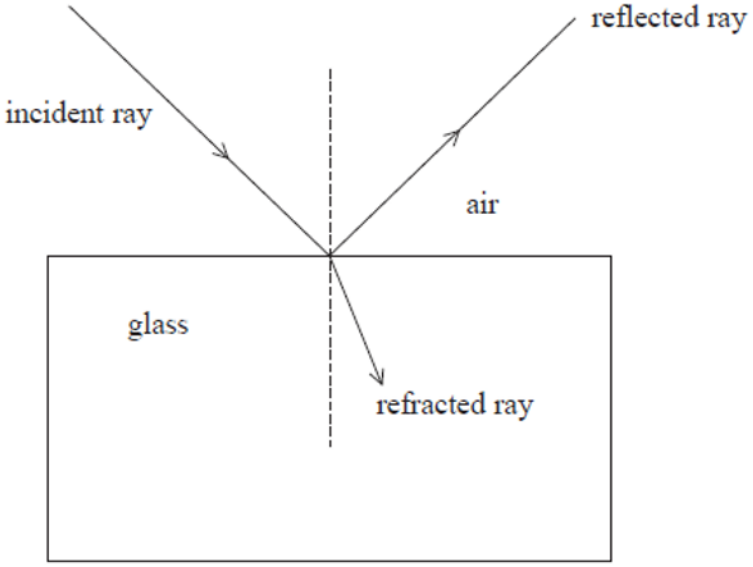
☒ **C** The light intensity does not change.

☒ **D** The light intensity is zero throughout the rotation.

(Total for question = 1 mark)

Q2.

When an incident ray of light meets a boundary between air and glass, some of the light is reflected and some is refracted, as shown.



The reflected light is partially plane polarised.

(a) State what is meant by plane polarised.

(2)

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(b) Deduce whether the refracted ray is unpolarised or partially plane polarised.

(2)

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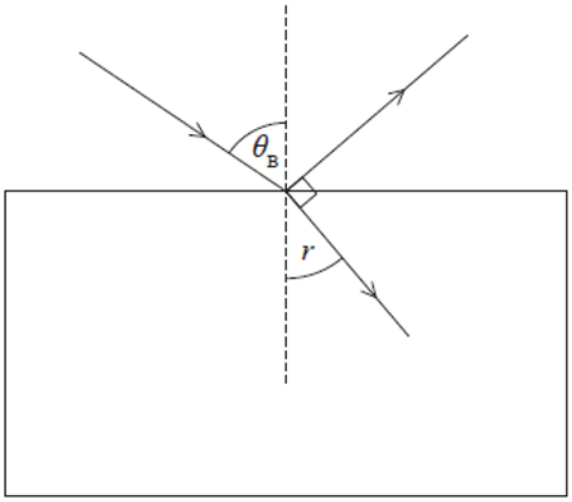
(c) At the Brewster angle θ_B, the reflected light is completely plane polarised. This occurs when the reflected ray and the refracted ray are at right angles to each other, so $\theta_B + r = 90°$



(i) Show that tan $\theta_B = \frac{n_g}{n_a}$

n_a = refractive index of air
n_g = refractive index of glass

(3)

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(ii) Calculate θ_B for light passing from air into glass.

refractive index of air = 1.00
refractive index of glass = 1.50

(2)

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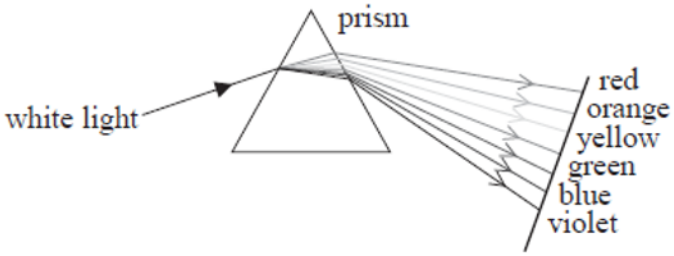
θ_B = ...

(iii) Different colours of visible light are refracted as they pass through a prism as shown.



A student suggests that the Brewster angle for violet light would be smaller than that for red light, as violet is refracted more than red.

Criticise this suggestion.

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(Total for question = 11 marks)

Q3.

Light travels at a speed of 2.3×10^8 m s^{-1} in water and 2.0×10^8 m s^{-1} in glass.
The refractive index of glass is 1.5

Which of the following expressions can be used to determine the refractive index of water?

☒ **A** $\frac{(2.3 \times 10^8) \times 1.5}{(2.0 \times 10^8)}$

☒ **B** $\frac{(2.0 \times 10^8) \times 1.5}{(2.3 \times 10^8)}$

☒ **C** $\frac{(2.0 \times 10^8)}{(2.3 \times 10^8) \times 1.5}$

☒ **D** $\frac{(2.3 \times 10^8)}{(2.0 \times 10^8) \times 1.5}$

(Total for question = 1 mark)

Q4.

Which of the following can **not** be demonstrated in experiments using sound waves?

(1)

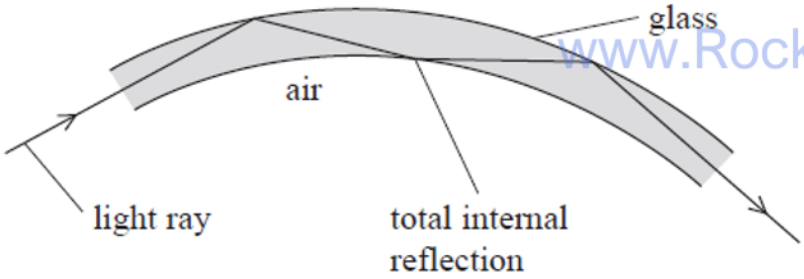
- ☒ **A** diffraction
- ☒ **B** polarisation
- ☒ **C** refraction
- ☒ **D** superposition

(Total for question = 1 mark)

Q5.

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)

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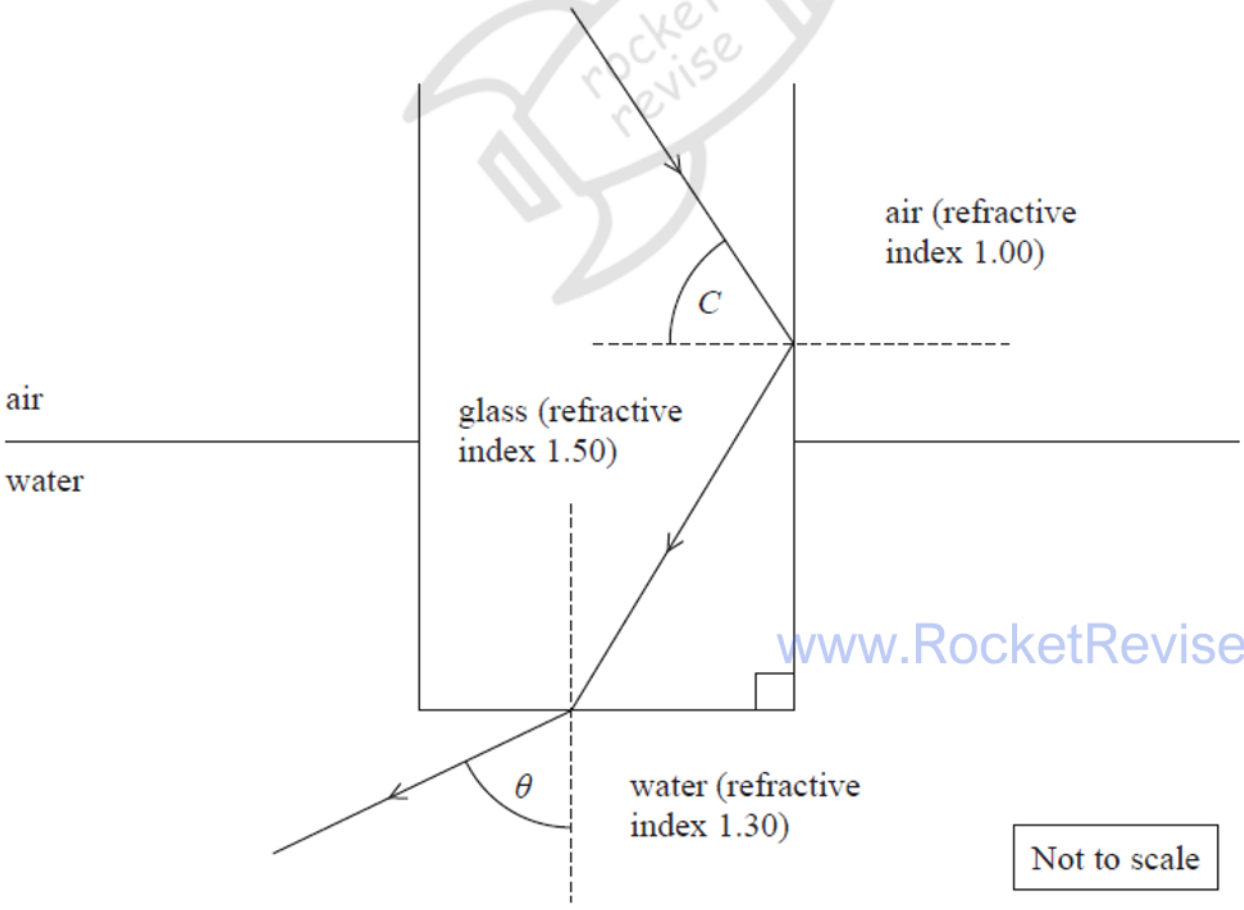
(c) The diagram shows a ray of light being totally internally reflected at one side of a glass fibre and then refracting as it leaves the end of the fibre. The angle of incidence at the boundary between the glass fibre and air is equal to the critical angle *C* for the glass-air interface. The ray enters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



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

(4)

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θ = ...

(Total for question = 8 marks)

Q6.

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

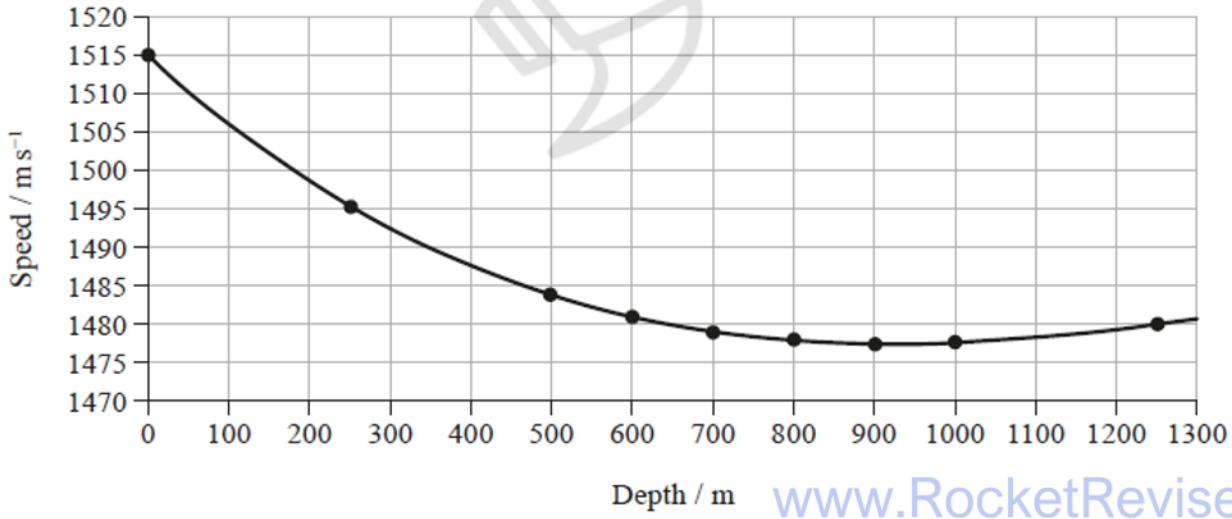

Diagram A

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.

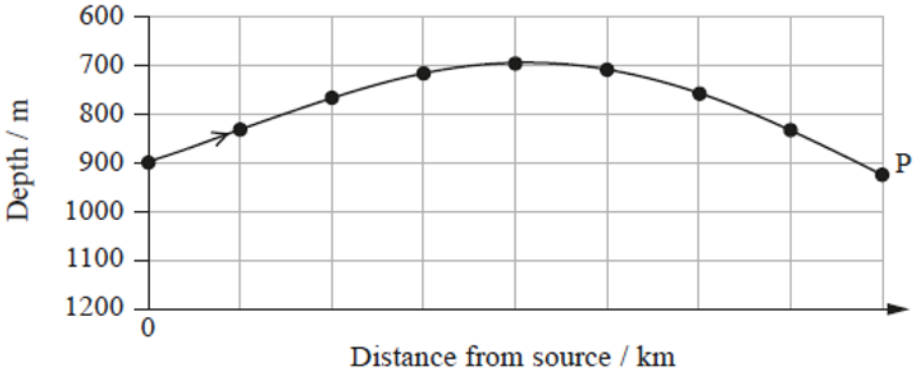

Diagram B

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

Your answer should refer to refraction and diagram A.

(5)

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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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(Total for question = 9 marks)

Q7.

Which of the following describes the oscillations in polarised waves?

☒ **A** in a single plane which is perpendicular to the direction of wave travel

☒ **B** in many planes, which include the direction of wave travel

☒ **C** in many directions and parallel to the direction of wave travel

☒ **D** in one direction and perpendicular to the direction of wave travel

(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 ☒ .

Which of the following statements about waves is correct?

☒ **A** Both longitudinal and transverse waves can be polarised.

☒ **B** Neither longitudinal nor transverse waves can be polarised.

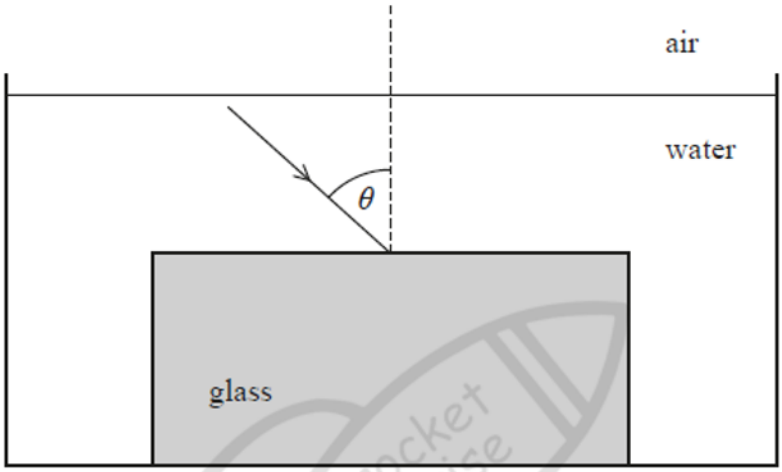
☒ **C** Only longitudinal waves can be polarised.

☒ **D** Only transverse waves can be polarised.

(Total for question = 1 mark)

Q9.

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 $\theta = 43.0°$.

(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 = ...

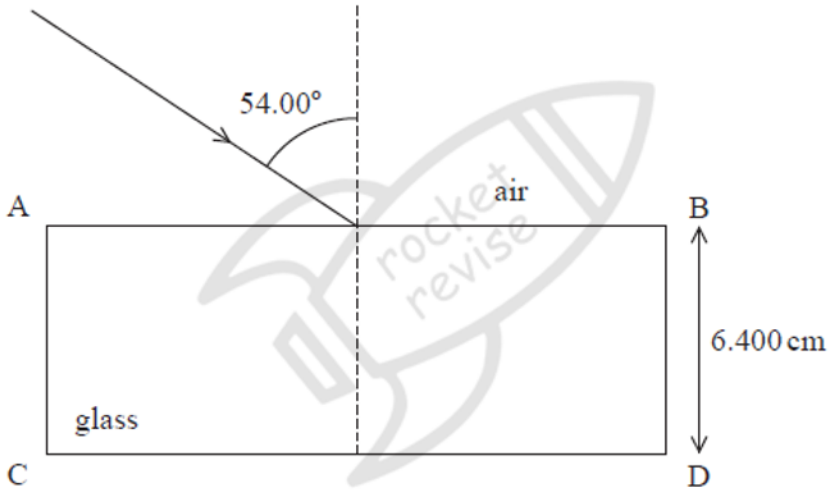
(Total for question = 4 marks)

Q10.

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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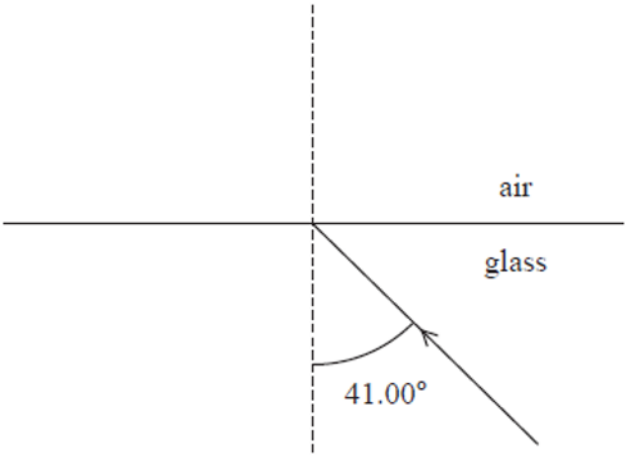
Distance between points = ...

(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.

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(Total for question = 9 marks)

Q11.

When unpolarised light passes through a polarising filter, the light becomes plane polarised.

(a) Explain the difference between unpolarised and plane polarised light.

(3)

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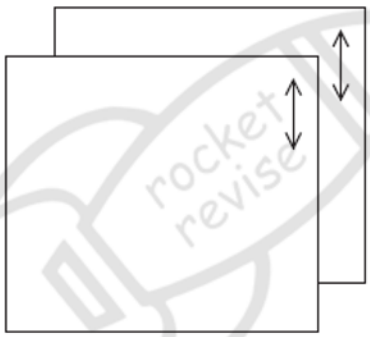
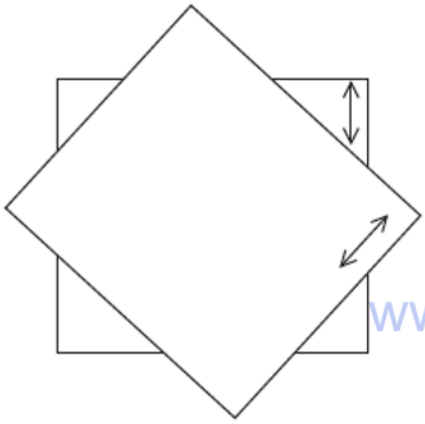
(b) An unpolarised light source is directed towards a screen. The intensity of radiation measured at the screen
is 1.00 W m^{-2}.

Two polarising filters are placed between the light source and the screen.
Initially there is an angle of 0° between their planes of polarisation, as shown.

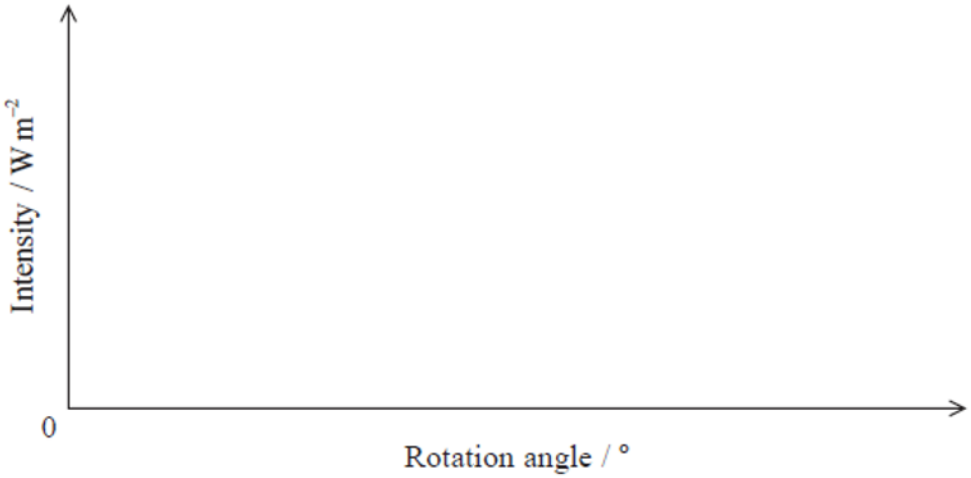


One of the polarising filters is then rotated, as shown.



Sketch a graph to show how the intensity of light measured at the screen varies as the filter is rotated from 0° to 90°.

(3)

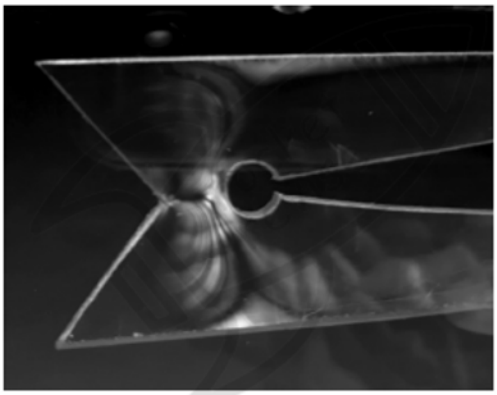


(c) Polarisation can be used to identify when some materials are under stress. Placing the material under stress causes the

plane of polarisation of the light passing through the material to be rotated. The greater the stress, the greater the

rotation of the plane of polarisation of the light.

A piece of transparent material under stress is positioned between two polarising filters. There is an angle of 90° between the planes of polarisation of the two polarising filters.



Explain how this photograph can be used to identify areas of the material with different amounts of stress.

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(Total for question = 9 marks)

Q12.

A physics teacher placed a coin at the bottom of a cup.

When viewing the cup from an angle, the coin was not visible, as shown in Photograph 1.

Photograph 1

While still observing from the same angle, the teacher slowly poured water into the cup. The coin gradually became visible, as shown in Photograph 2.

Photograph 2

This effect is caused by refraction.

(a) Explain what is meant by refraction.

(2)

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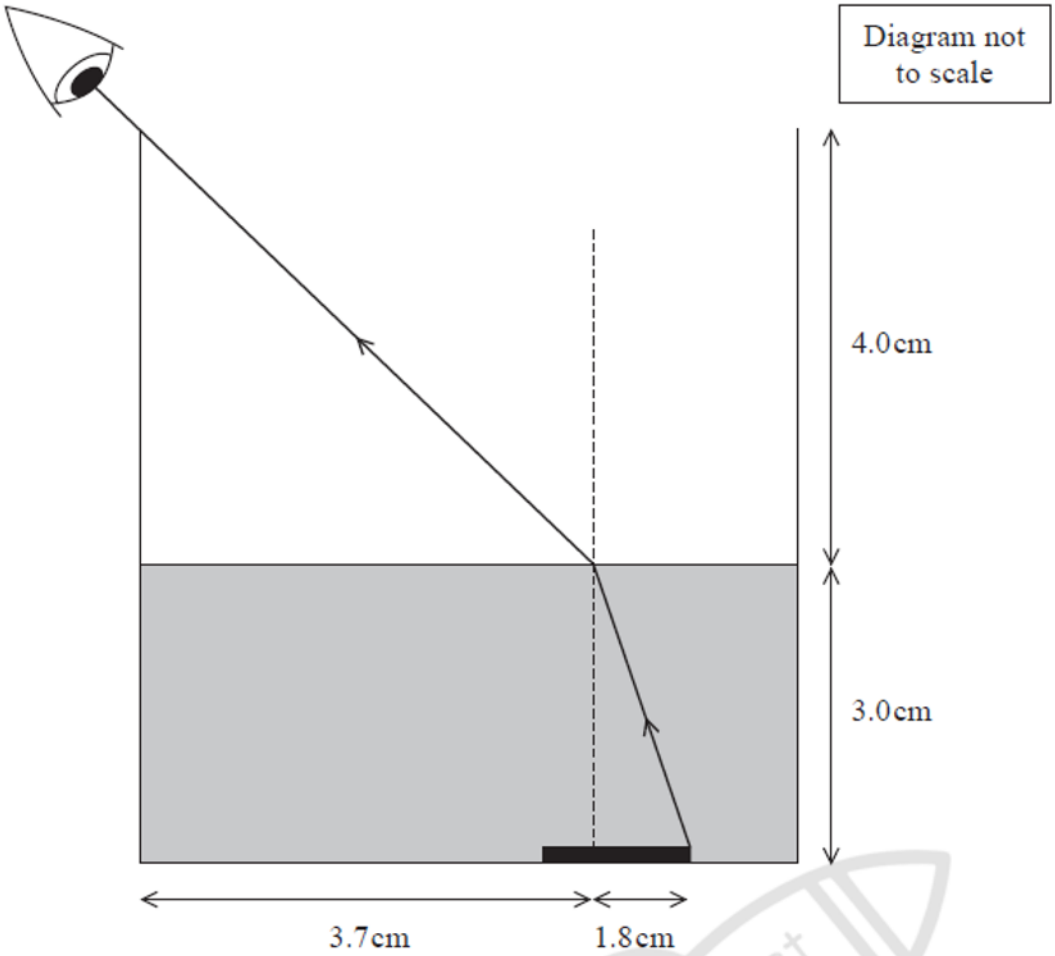
(b) The simplified diagram below shows how a ray of light travels from the edge of the coin to the teacher's eye, when the cup is partially filled with water.



Determine the refractive index of the water in the cup.

(3)

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Refractive index of water = ...

(Total for question = 5 marks)

Q13.

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)

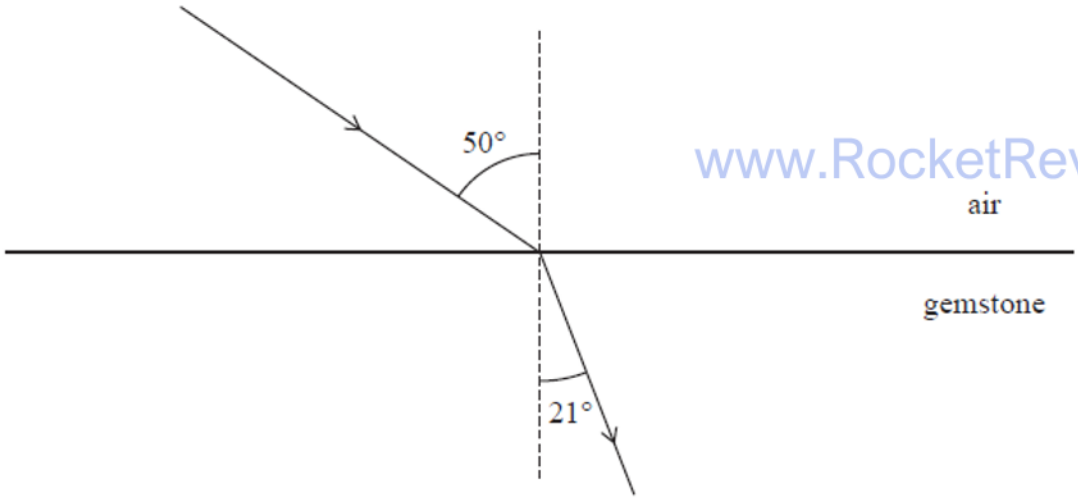
Q14.

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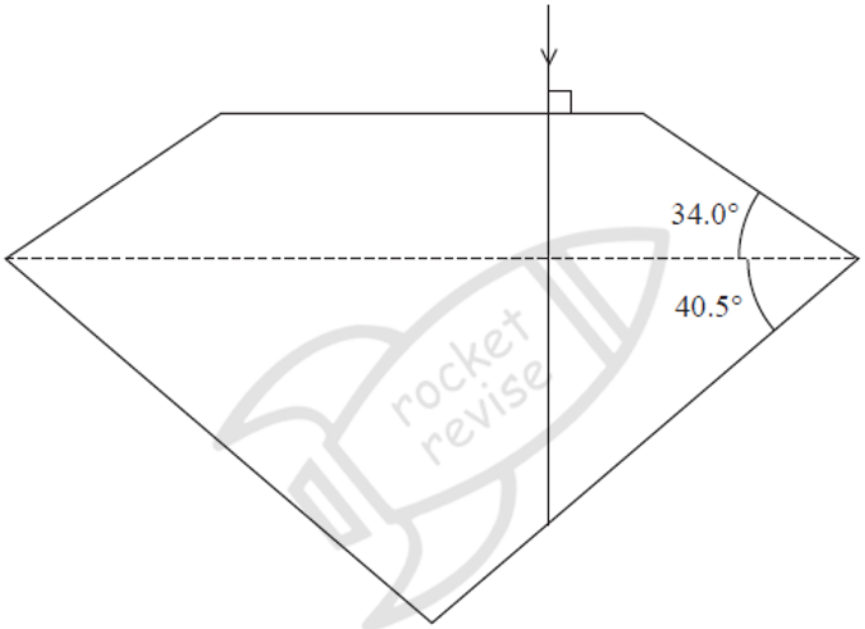
(b) Diamonds are cut into different shapes so that they 'sparkle' when light shines on them.

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.

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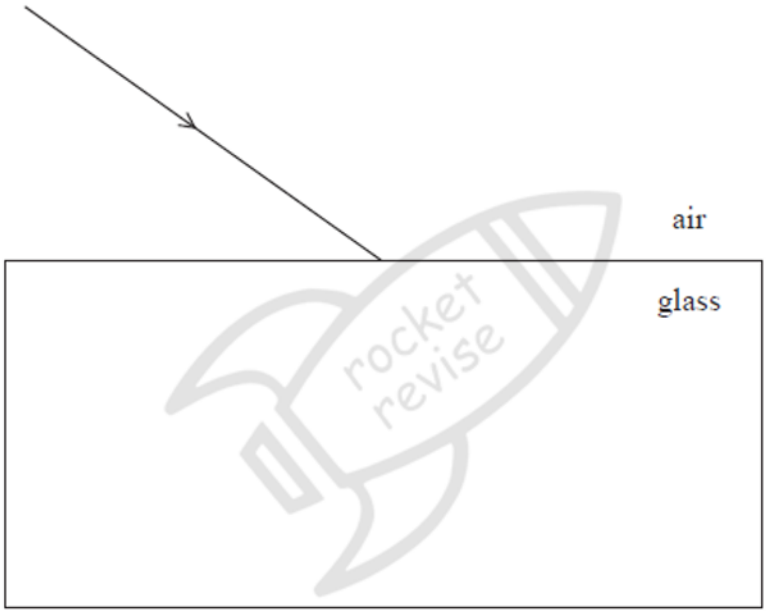
(Total for question = 9 marks)

Q15.

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

(5)

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(b) The speed of light in a different type of glass is 1.96×10^8 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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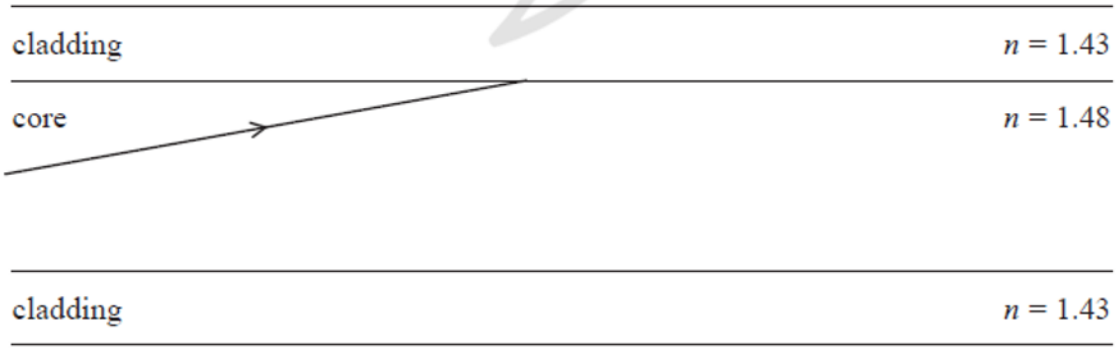
Critical angle = ...

(Total for question = 8 marks)

Q16.

An optical fibre consists of a core material surrounded by a material of lower refractive index called cladding.

A ray of light approaches the boundary between the core and the cladding, as shown.



(a) (i) Show that the critical angle for light incident on the boundary between the core and cladding is about 75°.

(3)

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(ii) Explain what will happen to the ray of light after it meets the boundary between the core and cladding.

The diagram is drawn to scale and you should use a measurement taken from the diagram.

(3)

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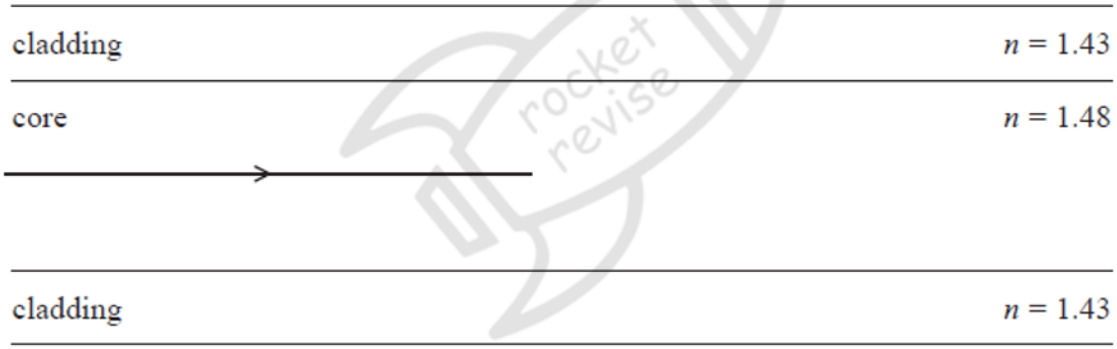
(b) The path of another ray of light through the core of the optical fibre is shown.



(i) Calculate the time taken for light to travel in a straight line along 70.0 km of this optical fibre.

(3)

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Time taken = ...

(ii) Light may escape from the core into the cladding when the optical fibre is curved.

A student suggests that using cladding with a lower refractive index would lead to less light

escaping from the core.

Explain why the student's suggestion is correct.

(2)

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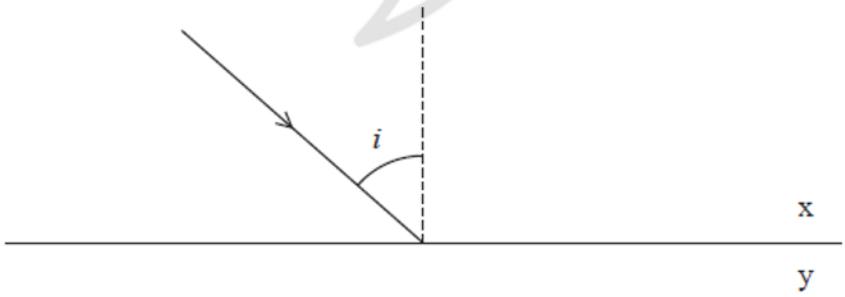
(Total for question = 11 marks)

Q17.

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?

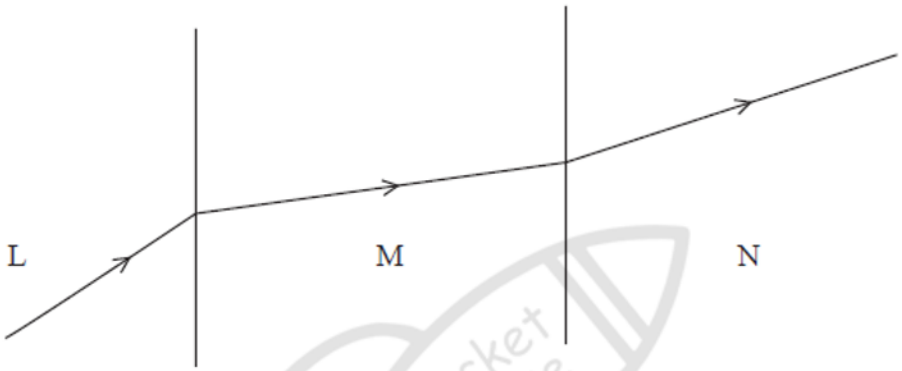
		Condition 1	Condition 2
☒	**A**	$i >$ critical angle	$n_x > n_y$
☒	**B**	$i >$ critical angle	$n_x < n_y$
☒	**C**	$i <$ critical angle	$n_x > n_y$
☒	**D**	$i <$ critical angle	$n_x < n_y$

(Total for question = 1 mark)

Q18.

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** $v_N > v_M > v_L$

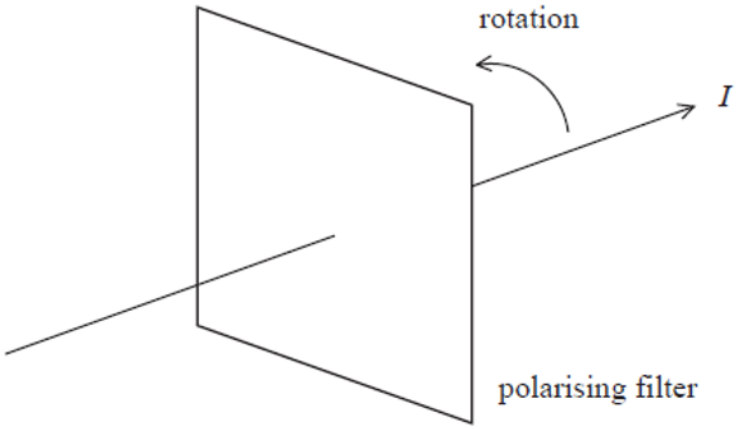
☒ **D** $v_M > v_N > v_L$

(Total for question = 1 mark)

Q19.

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 unpolarised light is incident on a polarising filter. The polarising filter transmits light of intensity I, as shown.



The polarising filter is then rotated in the direction shown on the diagram.

Which of the following gives the intensity of light transmitted after the filter has been rotated 90°?

☒ **A** 0

☒ **B** $\frac{I}{4}$

☒ **C** $\frac{I}{2}$

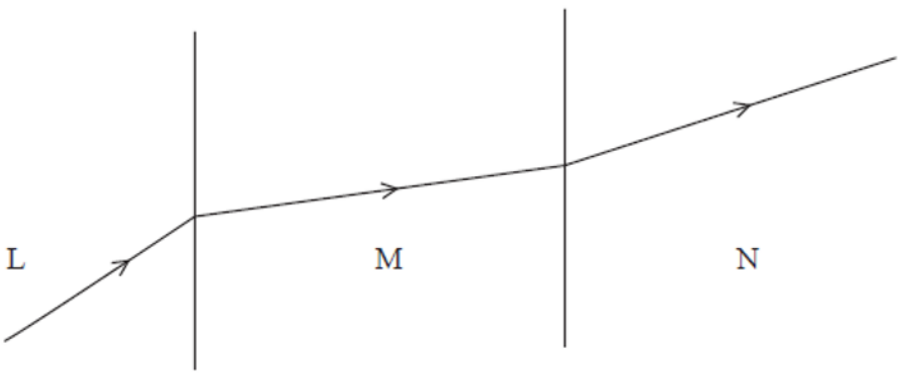
☒ **D** I

(Total for question = 1 mark)

Q20.

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 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

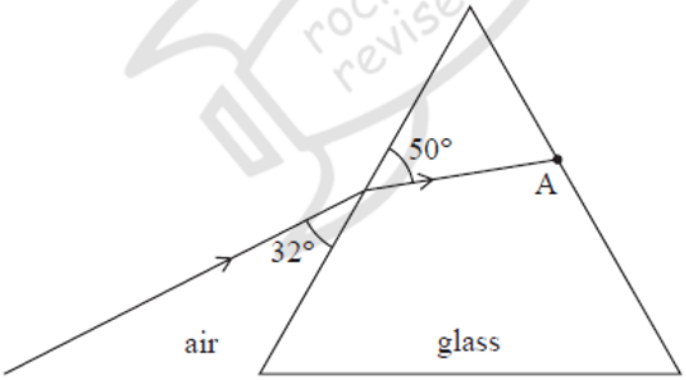
☒ **D** light travelling from N to M

(Total for question = 1 mark)

Q21.

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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Speed of light in glass = ...

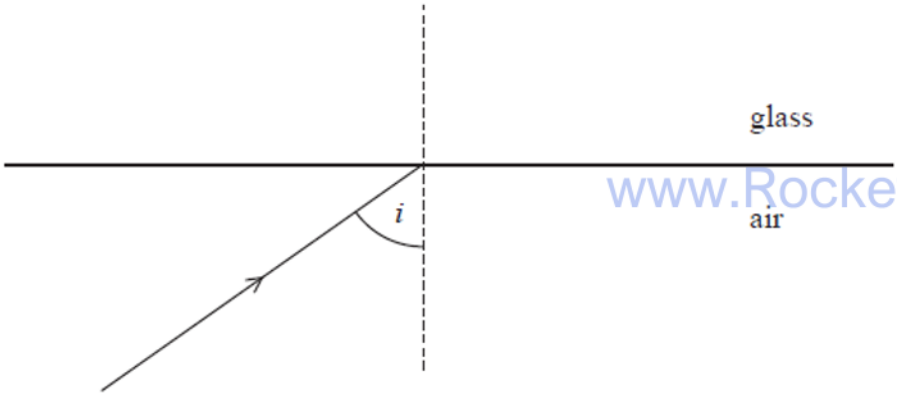
(Total for question = 6 marks)

Q22.

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)

Q23.

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 ☒.

Two photographs, X and Y, were taken of the same car windscreen. Photograph Y was taken through a polarising filter.

Photograph X

Photograph Y

(Source: © Etan J. Tal)

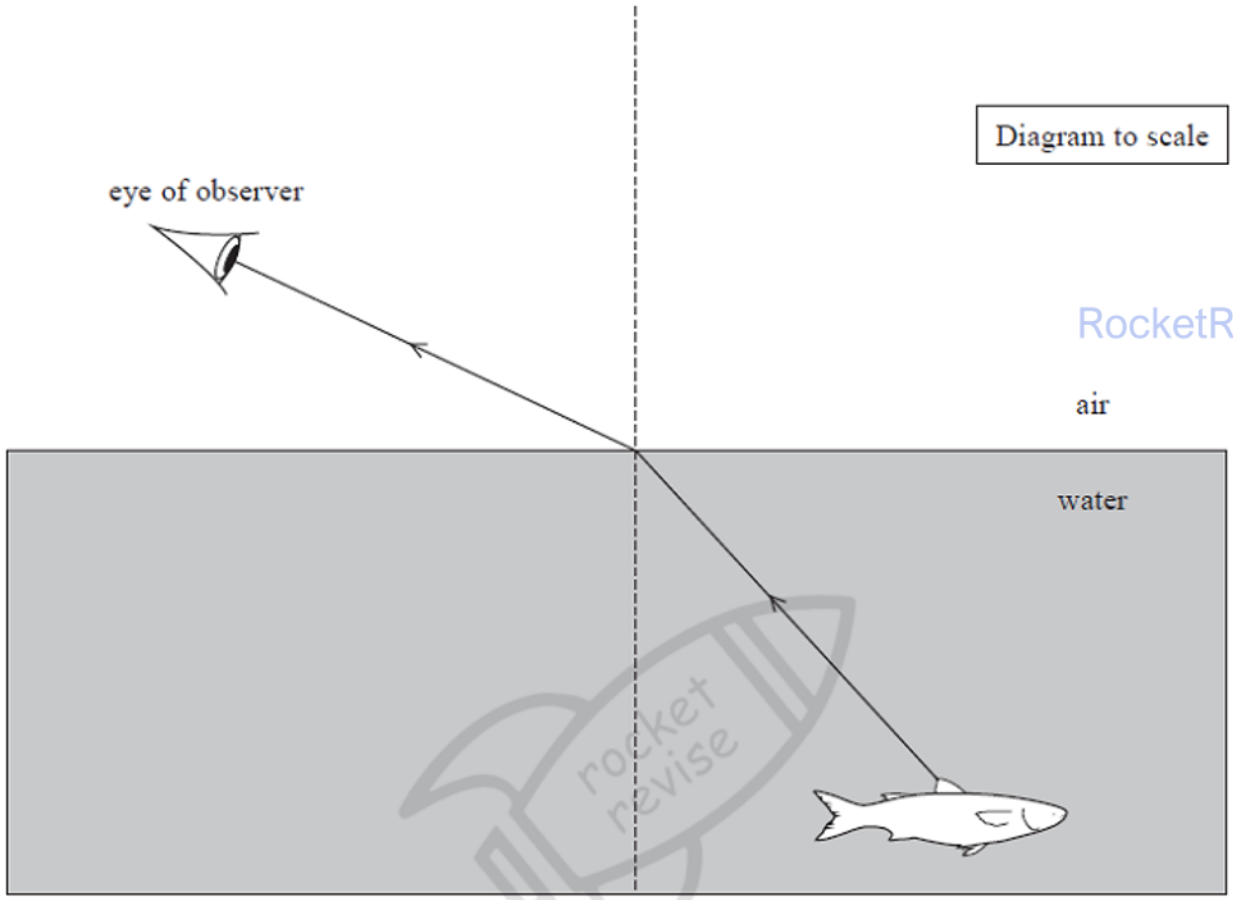
Which row of the table is correct?

		Light transmitted through windscreen	Light reflected from windscreen
☒	**A**	plane polarised	plane polarised
☒	**B**	plane polarised	unpolarised
☒	**C**	unpolarised	plane polarised
☒	**D**	unpolarised	unpolarised

(Total for question = 1 mark)

Q24.

The diagram shows a ray of light travelling from a fish to an observer. The ray of light refracts at the water-air boundary.



(a) Determine the refractive index of the water.

You should take measurements from the diagram.

(3)

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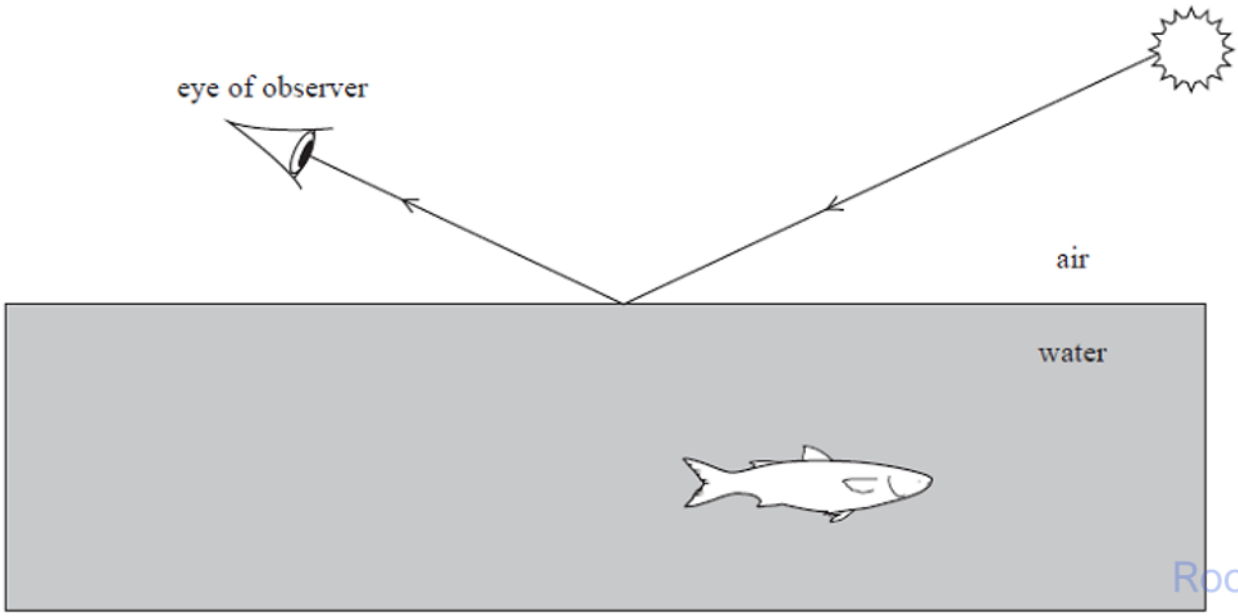
Refractive index = ...

(b) The diagram shows light from the Sun reflecting from the water surface into the eye of the observer.



The reflected light is partially plane polarised.

(i) Explain the difference between unpolarised and plane polarised light.

(3)

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(ii) Reducing the intensity of the reflected light would help the observer see the fish.

Explain how the observer can use a polarising filter to reduce the intensity of the reflected light.

(2)

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(Total for question = 8 marks)