

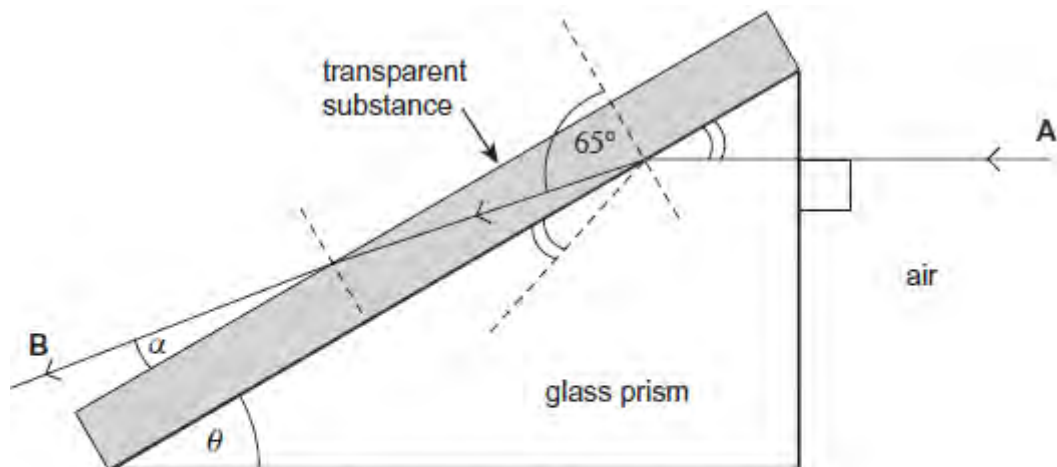
Q1.(a) Tick (✓) the appropriate boxes in the table to indicate how the wavelength, frequency and speed of light are affected when a ray of light travels from air into glass.

	Wavelength	Frequency	Speed
increases			
stays the same			
decreases			

(2)

(b) **Figure 1** shows a right-angled glass prism in contact with a transparent substance on one of the faces. One of the other angles of the prism is  $\theta$ .

**Figure 1**



refractive index of glass prism = 1.70

refractive index of transparent substance = 1.09

**angles are not shown to scale**

- (i) A ray **A** enters perpendicularly to one face of the prism. It is partially refracted and partially reflected at the interface between the glass and the transparent substance. The angle of refraction is  $65.0^\circ$ . The ray eventually leaves at an angle  $\alpha$  to the surface of the transparent substance.

Determine the angle  $\alpha$ .

angle  $\alpha = \dots\dots\dots$  degree

(2)

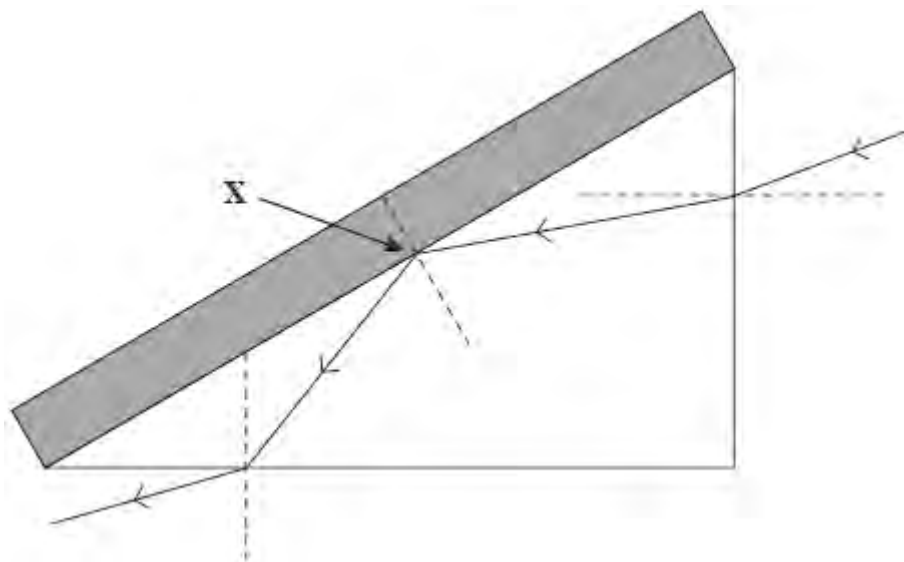
(ii) Determine the angle  $\theta$  in **Figure 1**.

angle  $\theta = \dots\dots\dots$  degree

(2)

(c) **Figure 2** shows another ray entering the prism.

**Figure 2**



(i) Identify the effect that takes place at **X** in **Figure 2**.

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(1)

- (ii) Explain, with a diagram, how the effect that occurs at **X** is used to transmit information along an optic fibre.

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(3)  
(Total 10 marks)

**Q2.**An optical fibre consists of a core, cladding and an outer sheath.

- (a) State the purpose of the outer sheath in an optical fibre.

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(1)

- (b) For one fibre, the speed of monochromatic light in the core is  $1.97 \times 10^8 \text{ m s}^{-1}$  and the speed in the cladding is  $2.03 \times 10^8 \text{ m s}^{-1}$ .

Calculate the critical angle for this light at the interface between the core and the cladding.

critical angle ..... degrees

(2)  
(Total 3 marks)

**Q3.(a)** Describe the structure of a step-index optical fibre outlining the purpose of the core and the cladding.

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(3)

(b) A signal is to be transmitted along an optical fibre of length 1200 m. The signal consists of a square pulse of white light and this is transmitted along the centre of a fibre. The maximum and minimum wavelengths of the light are shown in the table below.

Colour	Refractive index of fibre	Wavelength / nm
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Blue	1.467	425
Red	1.459	660

Explain how the difference in refractive index results in a change in the pulse of white light by the time it leaves the fibre.

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(2)

(c) Discuss **two** changes that could be made to reduce the effect described in part (b).

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(2)  
(Total 7 marks)

**Q4.** Monochromatic light may be characterised by its speed, frequency and wavelength. Which of the following quantities change when monochromatic light passes from air into glass?

**A** Speed only.



- B Speed and wavelength only.
- C Speed and frequency only.
- D Wavelength and frequency only.

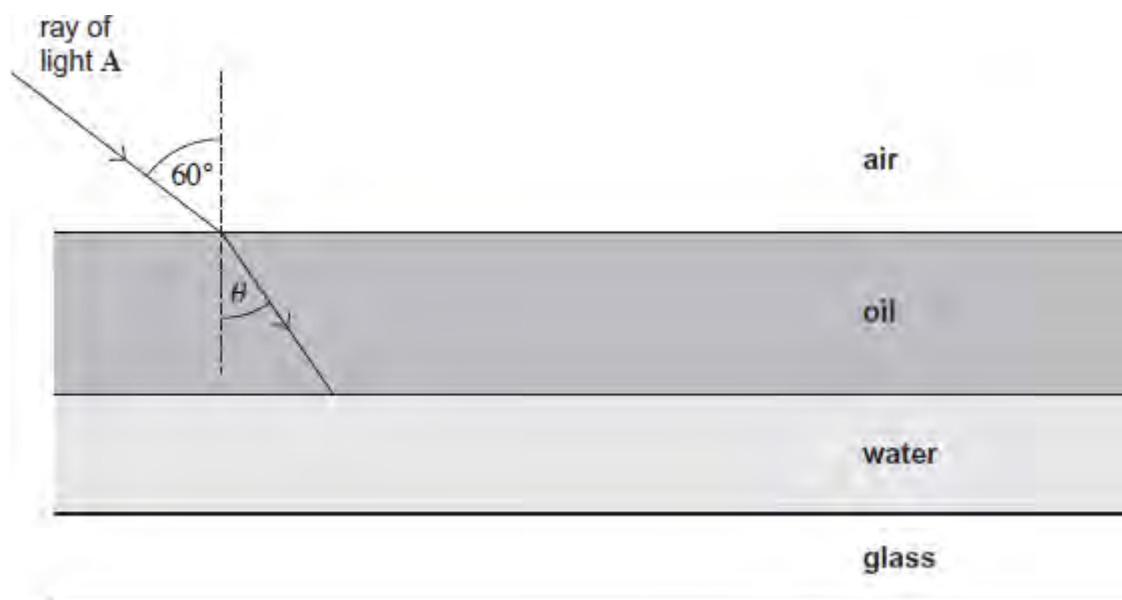
(Total 1 mark)

**Q5.** Figure 1 shows a ray of light A incident at an angle of  $60^\circ$  to the surface of a layer of oil that is floating on water.

refractive index of oil = 1.47

refractive index of water = 1.33

**Figure 1**



- (a) (i) Calculate the angle of refraction  $\theta$  in **Figure 1**.

angle ..... degrees

(2)

- (ii) Calculate the critical angle for a ray of light travelling from oil to water.

angle ..... degrees

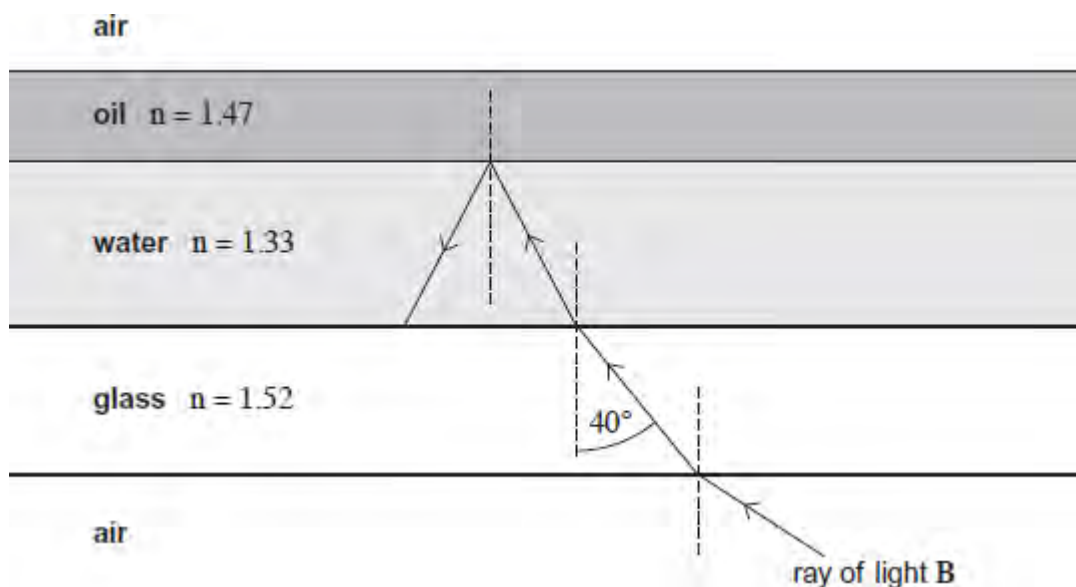
(2)

(iii) On **Figure 1** continue the path of the ray of light **A** immediately after it strikes the boundary between the oil and the water.

(2)

(b) In **Figure 2** a student has incorrectly drawn a ray of light **B** entering the glass and then entering the water before totally internally reflecting from the water–oil boundary.

**Figure 2**



The refractive index of the glass is 1.52 and the critical angle for the glass–water boundary is about  $60^\circ$ .

Give **two** reasons why the ray of light **B** would **not** behave in this way. Explain your answers.

reason 1 .....

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explanation .....

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reason 2 .....

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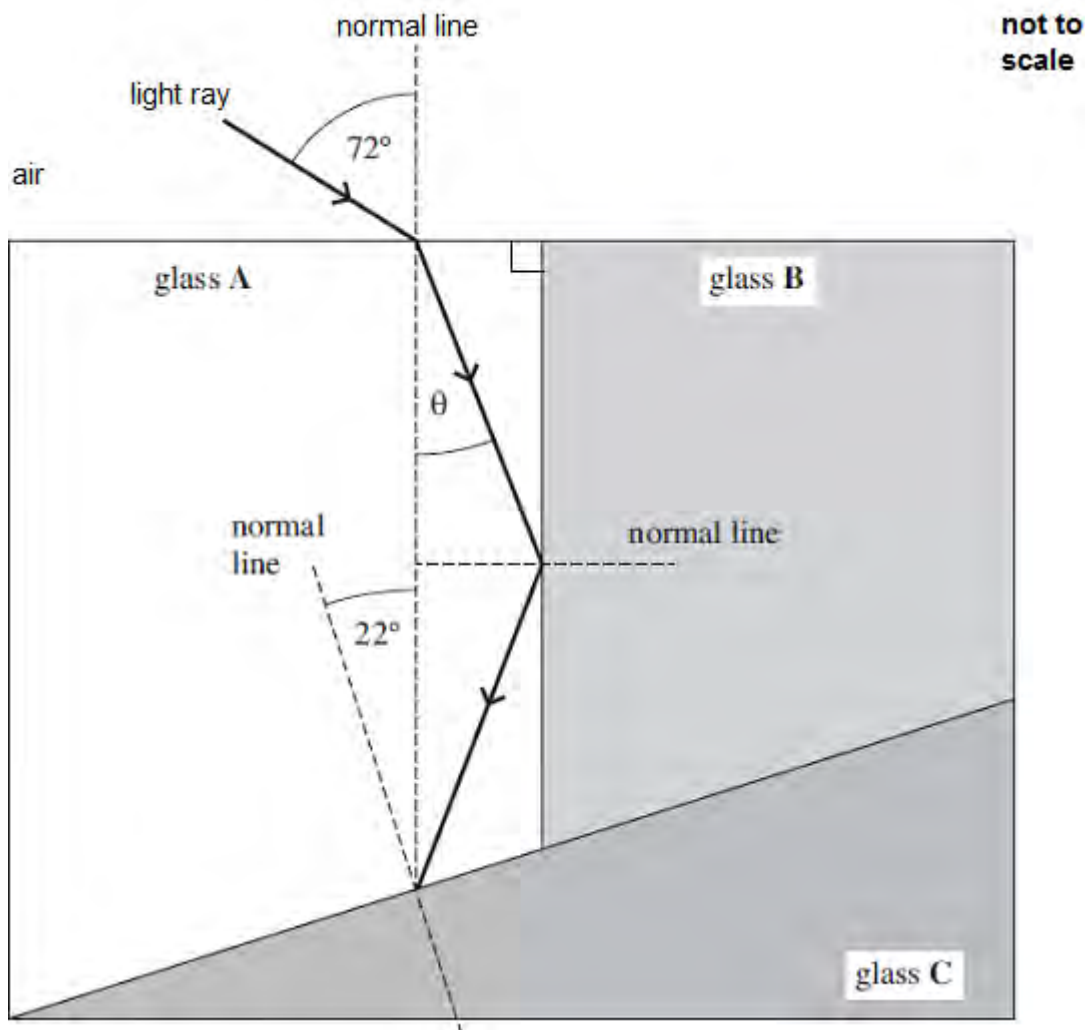
explanation .....

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(4)  
(Total 10 marks)

**Q6.** The diagram below shows three transparent glass blocks **A**, **B** and **C** joined together. Each glass block has a different refractive index.





- (a) State the **two** conditions necessary for a light ray to undergo total internal reflection at the boundary between two transparent media.

condition 1 .....

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condition 2 .....

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(2)

- (b) Calculate the speed of light in glass **A**.

refractive index of glass **A** = 1.80

speed of light .....  $\text{ms}^{-1}$

(2)

- (c) Show that angle is about  $30^\circ$ .

(2)

- (d) The refractive index of glass **C** is 1.40.

Calculate the critical angle between glass **A** and glass **C**.

critical angle ..... degrees

(2)

- (e) (i) State and explain what happens to the light ray when it reaches the boundary

between glass **A** and glass **C**.

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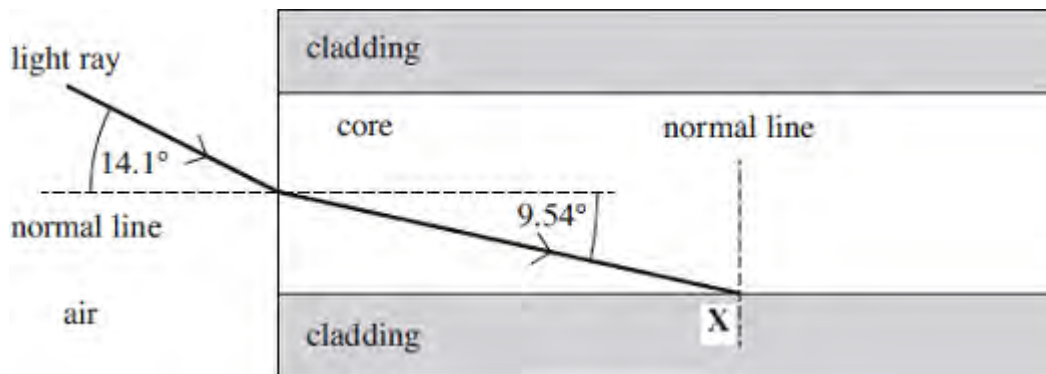
(2)

- (ii) On the diagram above continue the path of the light ray after it strikes the boundary between glass **A** and glass **C**.

(1)

(Total 11 marks)

**Q7.** The diagram below shows a section of a typical glass step-index optical fibre used for communications.



- (a) Show that the refractive index of the core is 1.47.

(1)

- (b) The refracted ray meets the core-cladding boundary at an angle exactly equal to the critical angle.

- (i) Complete the diagram above to show what happens to the ray after it strikes the boundary at **X**.

(2)

- (ii) Calculate the critical angle.

critical angle = .....degrees

(1)

(iii) Calculate the refractive index of the cladding.

refractive index = .....

(2)

(c) Give **two** reasons why optical fibres used for communications have a cladding.

reason 1.....

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reason 2.....

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(2)

(Total 8 marks)