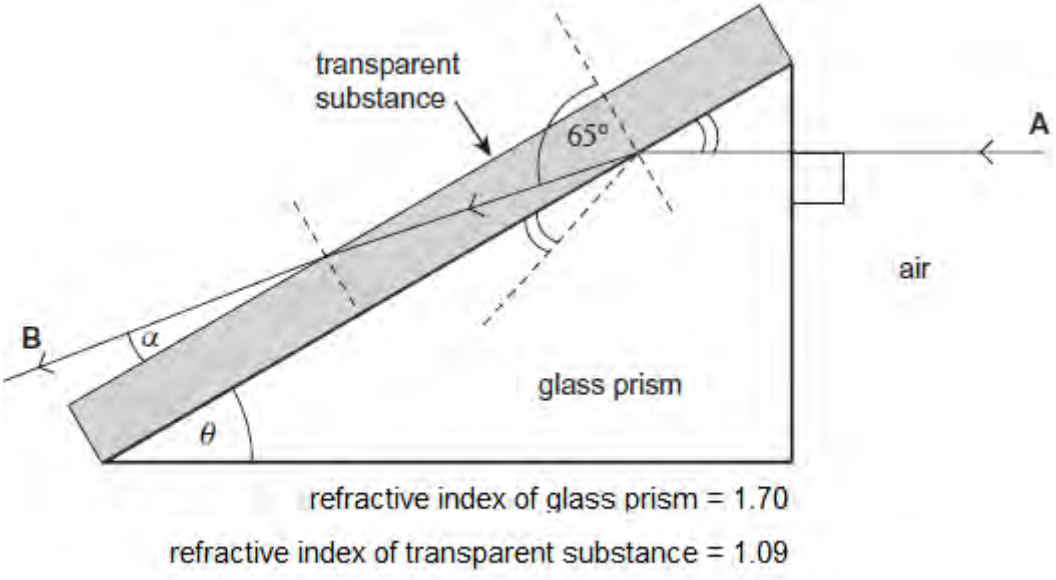
Q1.(a) Tick (✓) the appropriate boxes in the table to indicate how the wavelength, frequency and speed of light are affected when a ray of light travels from air into glass.

	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 θ.

Figure 1



(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°. The ray eventually leaves at an angle α to the surface of the transparent substance.

Determine the angle α.

angle α = ... degree

(2)

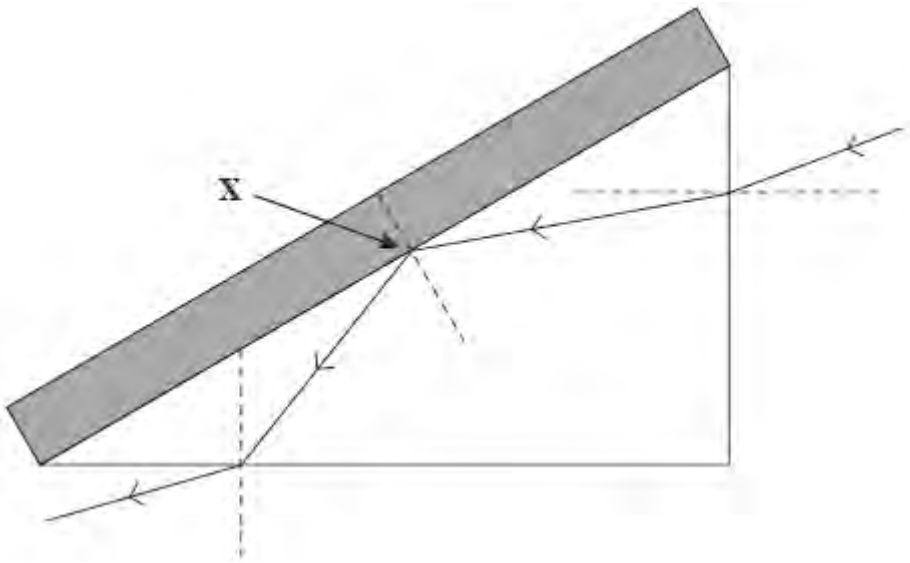
(ii) Determine the angle θ in **Figure 1**.

angle θ = ... 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**.

.....

(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.

.....

.....

(1)

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

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.....

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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

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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.....

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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. ⬭

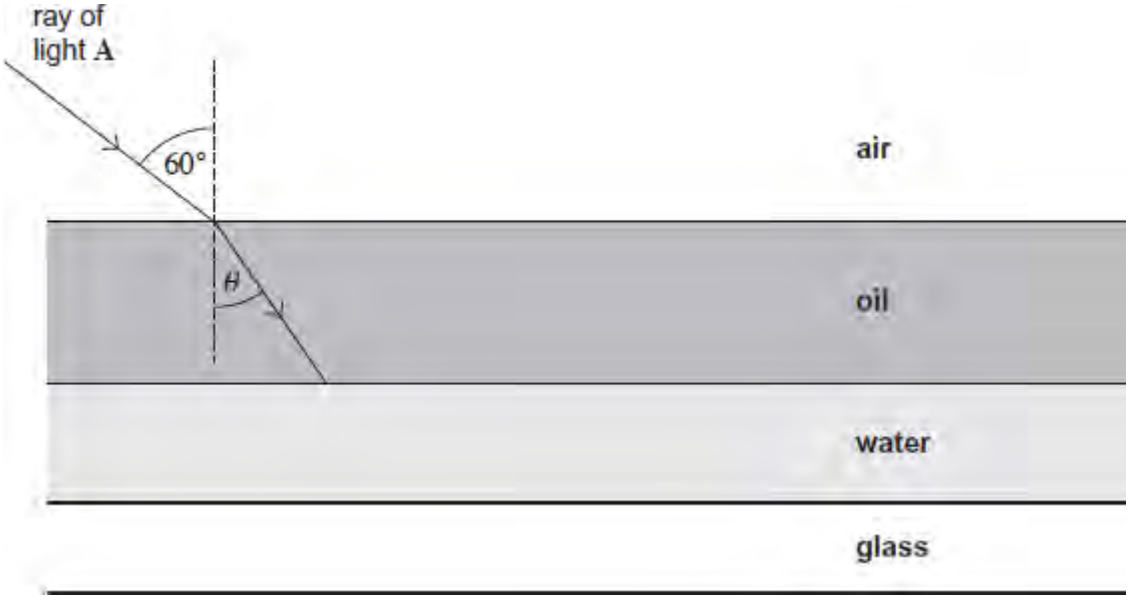
(Total 1 mark)

Q5.Figure 1 shows a ray of light **A** incident at an angle of 60° 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 θ in **Figure 1**.

angle ..... degrees

(2)

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

angle ..... degrees

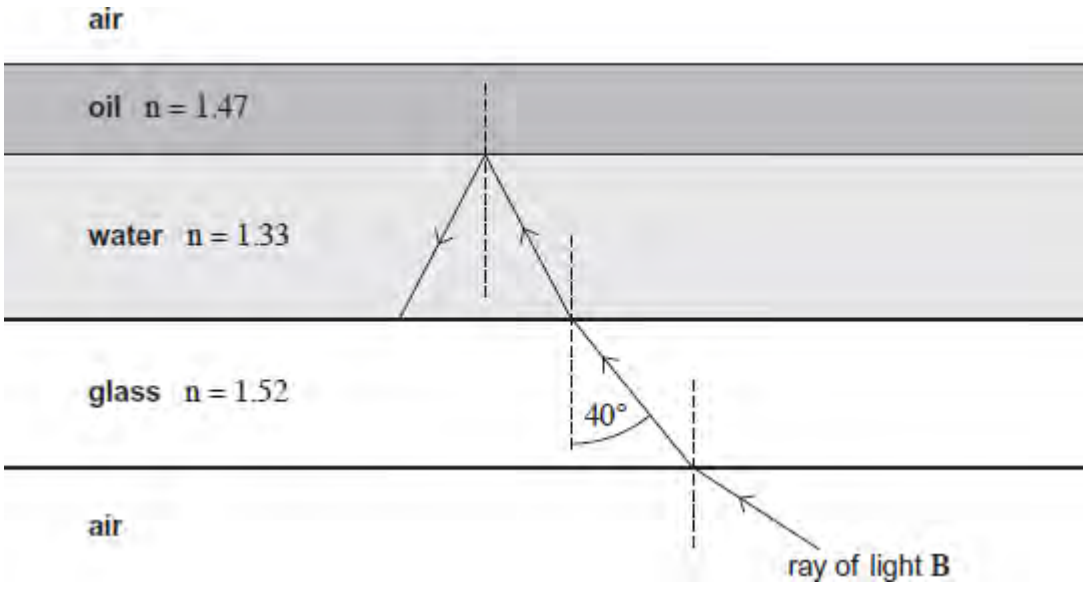
(2)

(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°.

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

reason 1 .....

.....

explanation .....

.....

.....

reason 2 .....

.....

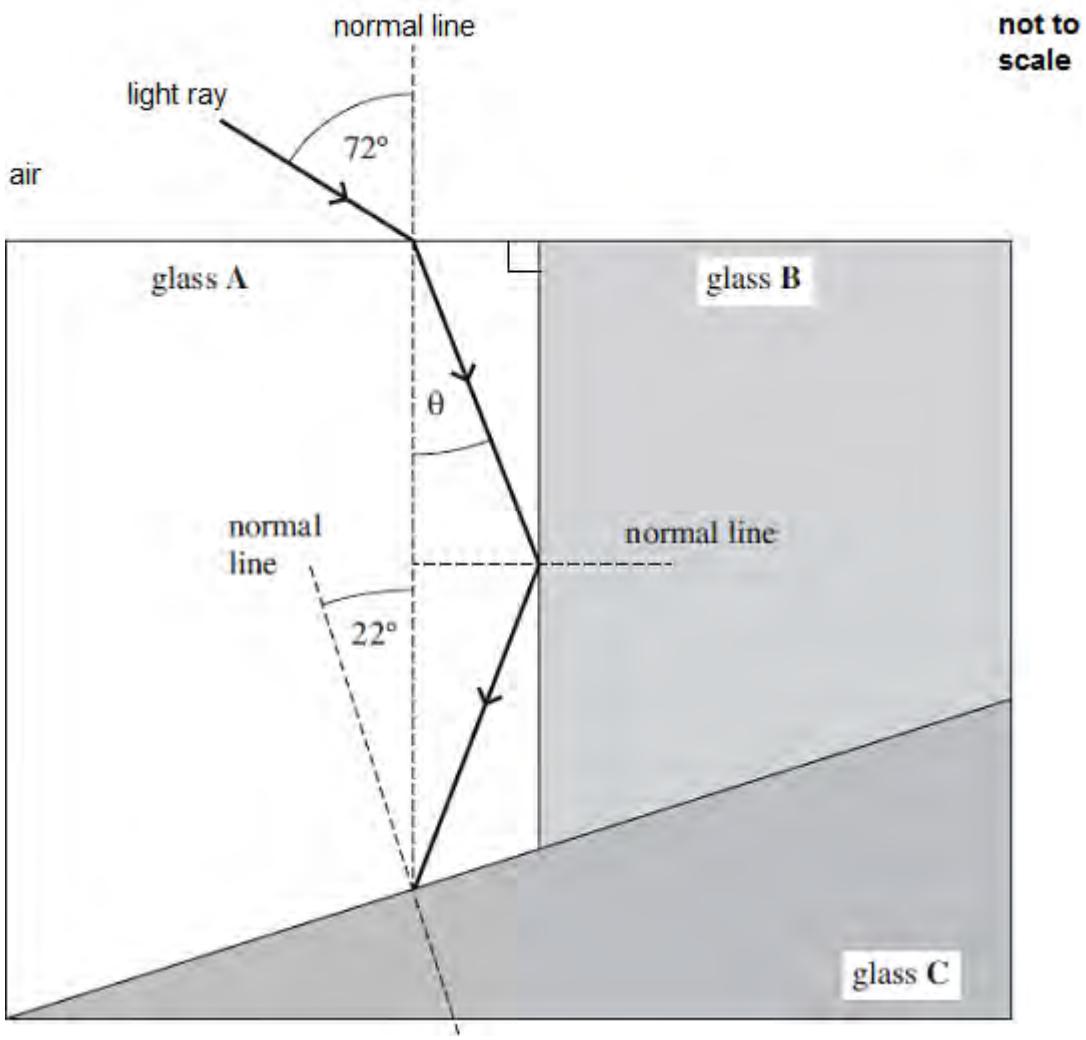
explanation .....

.....

.....

(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 .....

.....

condition 2 .....

.....

(2)

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

refractive index of glass **A** = 1.80

speed of light ..... ms^{-1}

(2)

(c) Show that angle is about 30°.

(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**.

.....

.....

.....

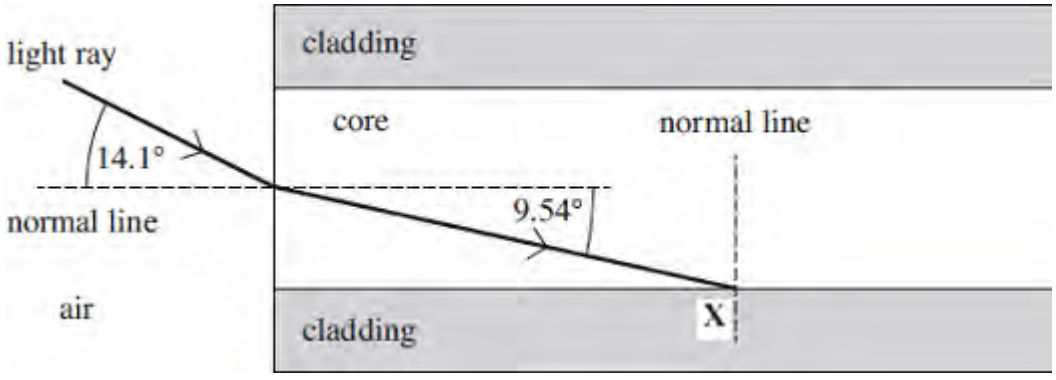
(2)

(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.....

.....

reason 2.....

.....

(2)

(Total 8 marks)