Q1.

A pulse-echo technique, using ultrasound, can be used to produce images of an unborn baby as shown.

Explain how the ultrasound scan of the unborn baby is produced.

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(Total for question = 6 marks)

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 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.

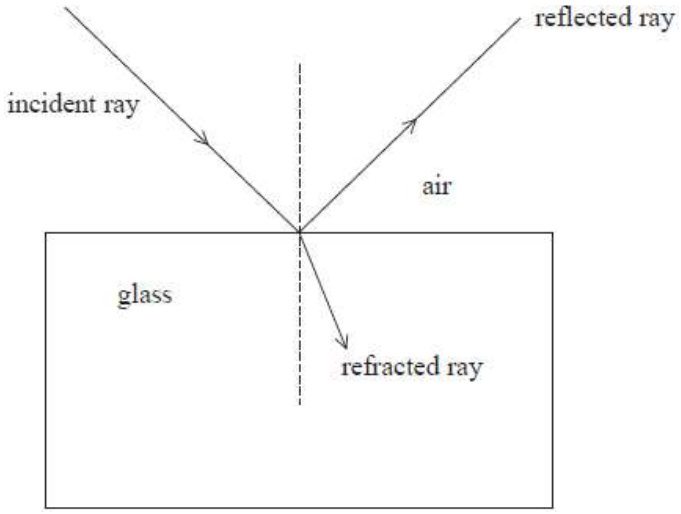
☐ **C** The light intensity does not change.

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

(Total for question = 1 mark)

Q3.

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.

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

(2)

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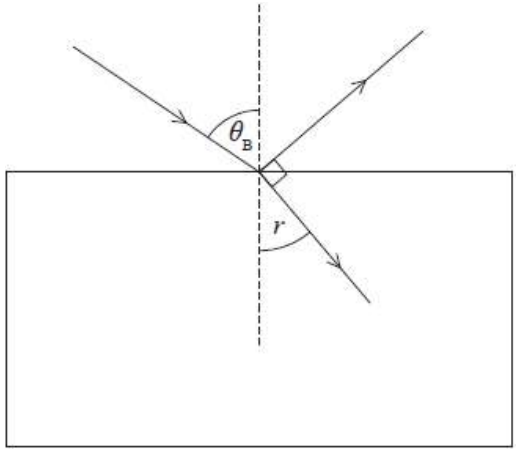
(c) At the Brewster angle θ_B, the reflected light is completely plane polarised. This occurs when the reflected ray and the refracted ray are at right angles to each other, so $\theta_B + r = 90°$



(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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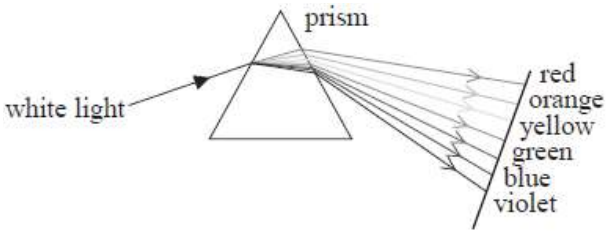
θ_B = ...

(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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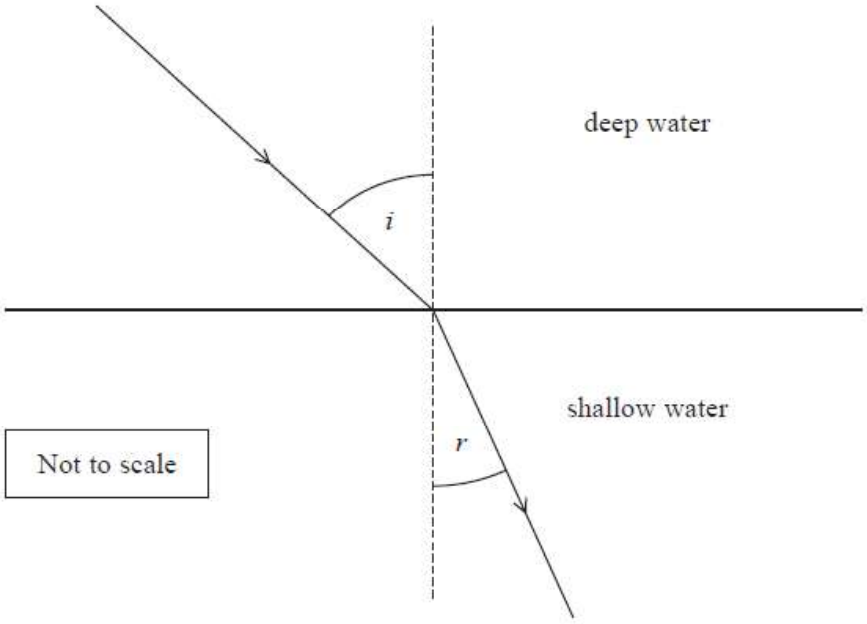
(Total for question = 11 marks)

Q4.

A water wave approaches a boundary between deep water and shallow water and is refracted. The diagram shows how the direction of travel of the wave changes.



(a) Explain why the wave is refracted as shown, as it travels from deep water into shallow water. You may add to the diagram.

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(b) When waves travel across the surface of water, their speed v is dependent on the depth d of the water and the wavelength λ of the waves.

For waves travelling in deep water, where $d > \frac{\lambda}{2}$, $v = \sqrt{\frac{g\lambda}{2\pi}}$

For waves travelling in shallow water, $v = \sqrt{(gd)}$

(i) Calculate the angle of refraction *r*.

wavelength of waves in deep water = 15 m
depth of deep water = 10 m
depth of shallow water = 0.50 m
angle of incidence = 40°

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r = ...

(ii) In 1933, the crew of the US Navy ship USS Rampo took measurements from one of the largest waves ever recorded. The wavelength of the wave was 342 m and the time period was 14.8 s.

Show that the depth of the water where the crew measured the wave was greater than 170 m.

(3)

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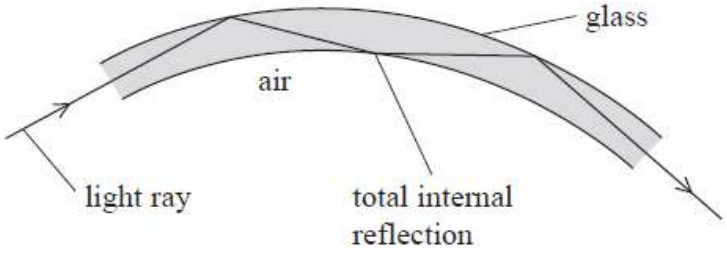
(Total for question = 10 marks)

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.

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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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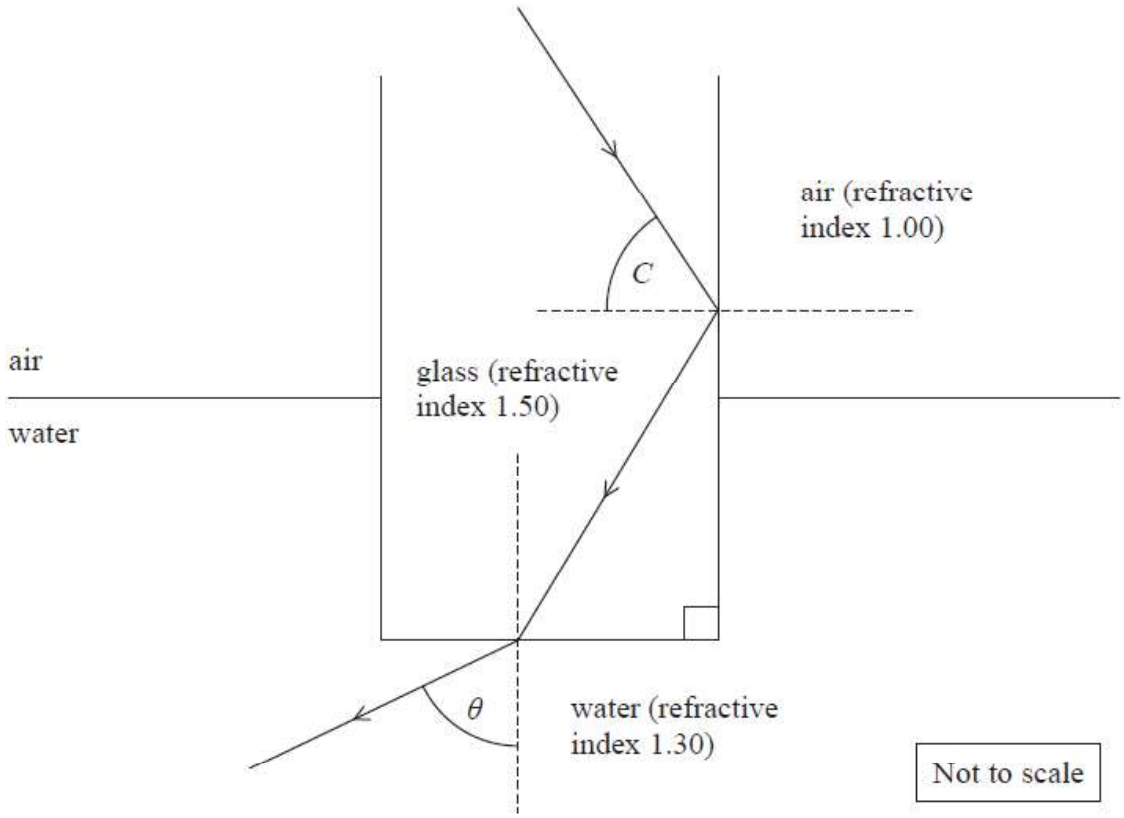
(c) The diagram shows a ray of light being totally internally reflected at one side of a

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.

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θ = ...

(Total for question = 8 marks)

Q6.

The rails of a railway track are usually made from steel, which can withstand the high stress of heavy trains. However, steel can develop cracks over time, leading to accidents if not repaired. Large cracks in a rail, such as the one shown in the photograph, are easy to observe.

(Source: *virginiabeach.legalexaminer.com*)

Ultrasound is commonly used to detect cracks that are too small to be seen. An ultrasound transducer transmits a pulse of ultrasound into the top of the rail and records the time taken for the pulse to return. If this time is less than the time expected for the pulse to return from the bottom of the rail, a crack is present.

(a) State why an ultrasound pulse would be reflected by a crack in a rail.

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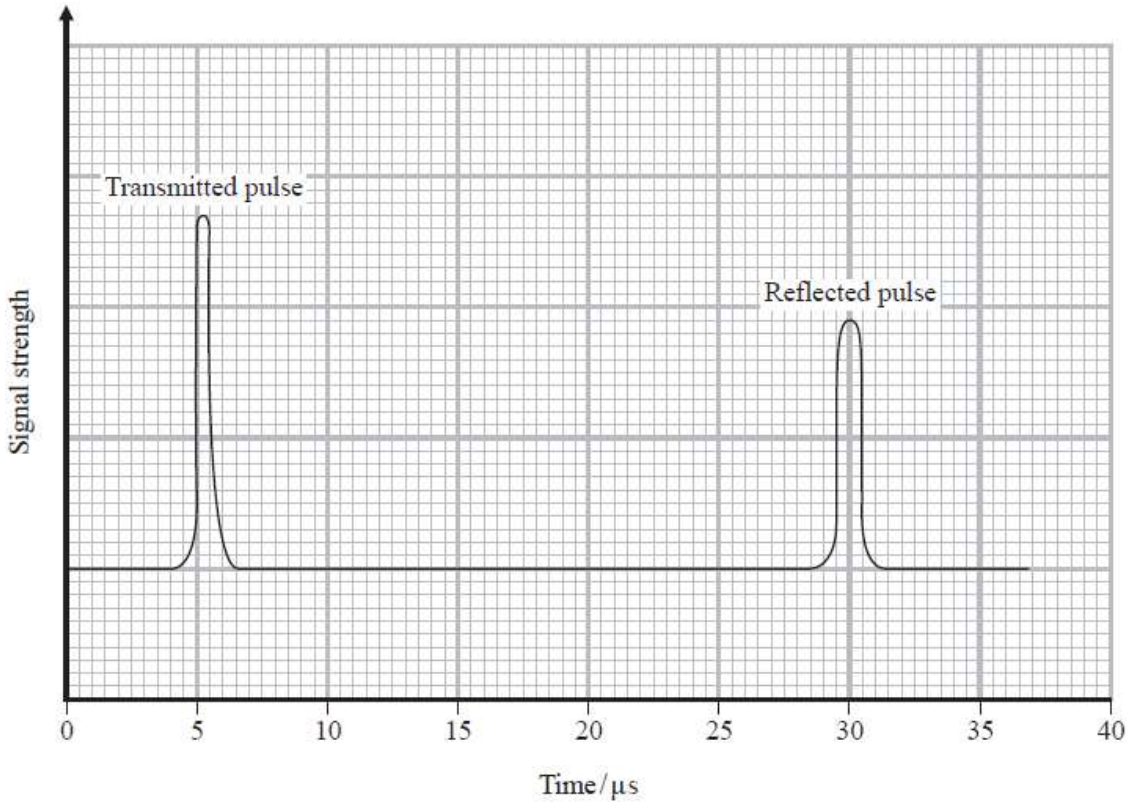
(b) A data logger connected to the transducer produces a graph of ultrasound signal strength against time.



Determine whether the reflected pulse is from a crack in the rail or from the bottom of the rail.

depth of rail = 15 cm
speed of ultrasound in steel = 5800 m s^{-1}

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(c) Suggest why this ultrasound method may not detect multiple cracks in a piece of rail.

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(d) To detect cracks, transducers are attached to the wheels of special trains.

Explain why these trains must travel much more slowly than passenger trains.

(2)

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(Total for question = 8 marks)