Light

1.

(a) State the two laws of refraction.

1. .....

.....

2. .....

..... [2]

(b) Fig. 1.1 shows a ray of light entering a glass prism.
speed of light in the glass = $2.0 \times 10^8 \, m \, s^{-1}$
speed of light in air = $3.0 \times 10^8 \, m \, s^{-1}$

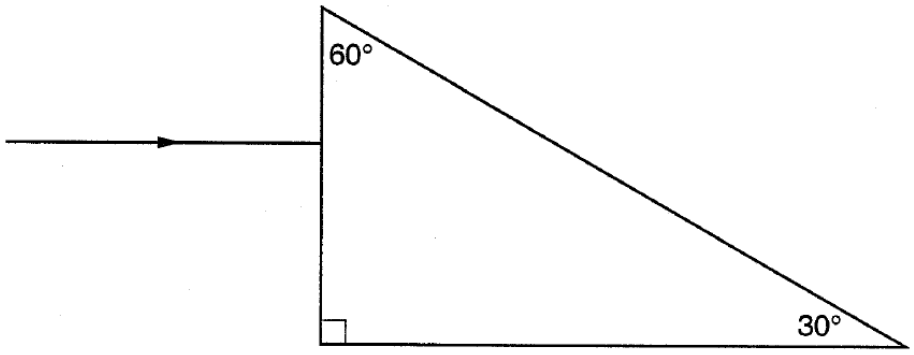

Fig. 1.1

(i) Calculate the refractive index of the prism's glass

refractive index = ... [2]

(ii) Calculate the critical angle for a glass/air interface of the prism.

critical angle = ... [2]

(iii) By drawing on Fig. 1.1 show the path of the ray inside the prism. [2]

(iv) Deduce the angle of incidence of the ray at the bottom surface.

angle of incidence = ... [1]

(v) Calculate the angle of refraction as the ray finally emerges from the prism.

angle of refraction = ... [3]

2.

(a) Define the *refractive index* of a transparent medium.

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.....[1]

(b) Fig. 1.1 shows a ray of light **X** emitted by a point light source embedded in a glass block of refractive index 1.49. The angle of incidence of **X** at the glass/air surface is 30°.

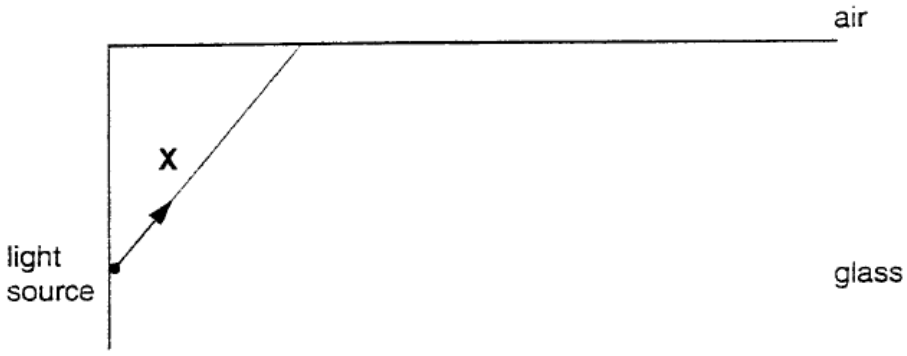

Fig. 1.1

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

angle of refraction = ... ° [3]

(ii) Complete Fig. 1.1 to show what happens to the ray **X** after it is incident at the glass/air interface. [2]

(iii) Calculate the critical angle at the glass/air interface.

critical angle = ... ° [2]

(iv) On Fig. 1.1 draw the complete path followed by another ray of light leaving the light source which reaches the glass/air interface at the critical angle (there is no need to measure the critical angle accurately but it should be labelled). [2]

(c) (i) Calculate the speed of light in glass of refractive index 1.49.

speed = ... $m\,s^{-1}$ [2]

(ii) Calculate the minimum time taken for a light pulse to travel from end to end along a straight glass fibre of length 50.0 km and refractive index 1.49.

time = ... s [2]

(iii) Suggest a reason why the time taken might be slightly greater than that calculated in **(ii)**.

.....

.....[1]

3.

(a) The speed of light in air is 3.00×10^8 m s^{-1}.

(i) Calculate the speed of light in glass of refractive index 1.52.

speed = ... m s^{-1} [2]

(ii) Calculate the speed of light in water of refractive index 1.33.

speed = ... m s^{-1} [1]

(iii) Calculate the refractive index for light travelling from water into this glass.

R.I. = [2]

(iv) Calculate the critical angle *C* for the water/glass interface.

C = ...° [2]

(v) Fig. 1.1 shows a water/glass interface. On Fig. 1.1, draw a labelled ray diagram to show what is meant by the critical angle for the water/glass interface. (There is no need to measure the critical angle, but it should be labelled as *C*). [3]

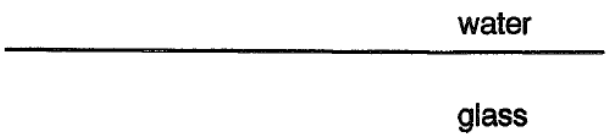

Fig. 1.1

(b) One drawback of using an optic fibre to transmit pulses of light is known as *multipath dispersion.*

(i) Explain what is meant by multipath dispersion.

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..... [3]

(ii) Suggest how multipath dispersion may be minimised.

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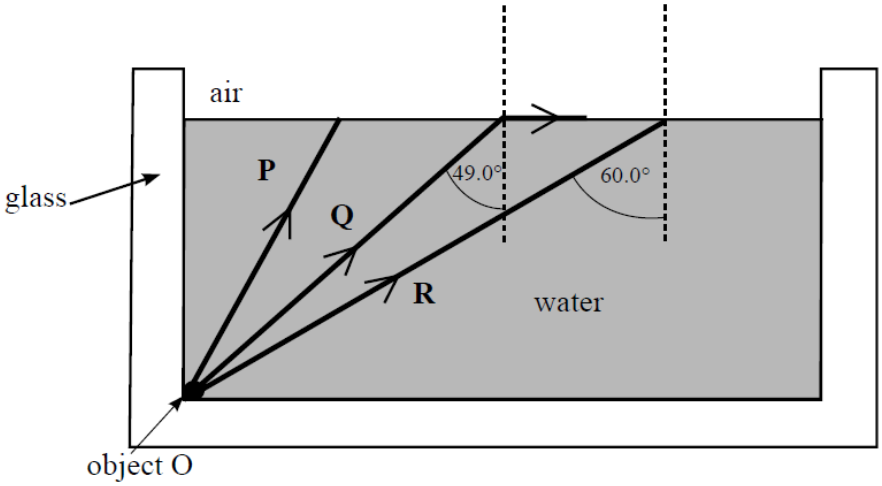
..... [2]

4.

Figure 6 shows a rectangular glass fish tank containing water. Three light rays, **P**, **Q** and **R** from the same point on a small object O at the bottom of the tank are shown.

Figure 6



(a) (i) Light ray **Q** is refracted along the water-air surface. The angle of incidence of light ray **Q** at the water surface is 49.0°. Calculate the refractive index of the water. Give your answer to an appropriate number of significant figures.

Answer.....

(1 mark)

(a) (ii) Draw on **Figure 6** the path of light ray **P** from the water-air surface.

(3 marks)

(b) In **Figure 6**, the angle of incidence of light ray **R** at the water-air surface is 60.0°.

(b) (i) Explain why this light ray is totally internally reflected at the water surface.

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.....

(2 marks)

(b) (ii) Draw the path of light ray **R** from the water surface and explain whether or not **R** enters the glass at the right-hand side of the tank.

the refractive index of the glass = 1.50

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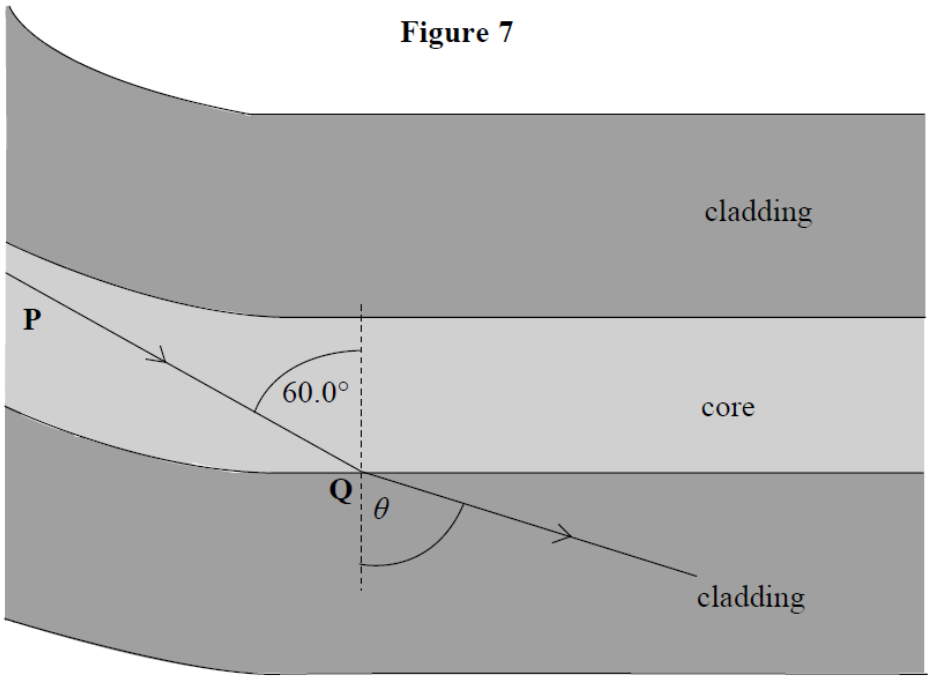
(4 marks)

5.

An optical fibre used for communications has a core of refractive index 1.55 which is surrounded by cladding of refractive index 1.45.

Figure 7



(a) **Figure 7** shows a light ray **P** inside the core of the fibre. The light ray strikes the core-cladding boundary at **Q** at an angle of incidence of 60.0°.

(a) (i) Calculate the critical angle of the core-cladding boundary.

answer.....degrees
(3 marks)

(a) (ii) State why the light ray enters the cladding at **Q**.

.....

.....
(1 mark)

(a) (iii) Calculate the angle of refraction, θ, at **Q**.

answer.....degrees
(3 marks)

(b) Explain why optical fibres used for communications need to have cladding.

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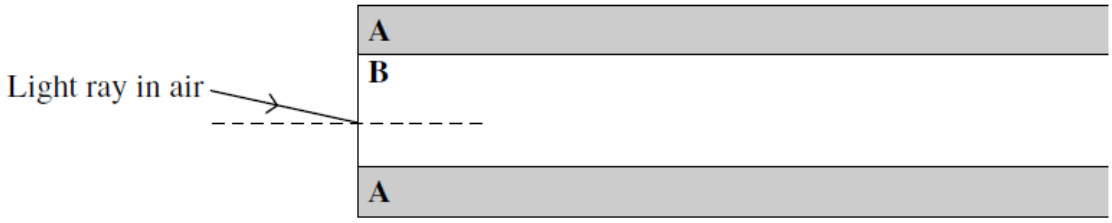
(2 marks)

6.

Figure 3 shows a cross-section through a step index optical fibre.

Figure 3



(a) (i) Name the parts **A** and **B** of the fibre.

(1 mark)

A	
B	

(a) (ii) On **Figure 3**, draw the path of the ray of light through the fibre. Assume the light ray undergoes *total internal reflection* at the boundary between **A** and **B**.

(2 marks)

(b) Calculate the critical angle for the boundary between **A** and **B**. Give your answer to an appropriate number of significant figures.

The refractive index of part **A** = 1.46
The refractive index of part **B** = 1.48

answer = ... degrees

(2 marks)

(c) State and explain **one** reason why part **B** of the optical fibre is made as narrow as possible.

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(2 marks)

(d) State **one** application of optical fibres and explain how this has benefited society.

Application

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Benefit

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(2 marks)