Light and refractive index

1 Fig. 7.1 shows a ray of light incident on a rectangular glass block at point X.

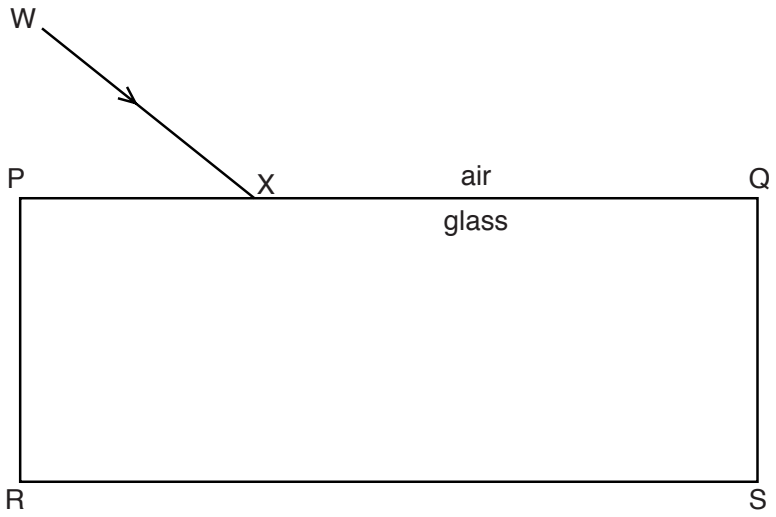

Fig. 7.1

The ray of light is refracted at X.

On Fig. 7.1,

(a) draw the normal at X, [1]

(b) draw the path of the ray through the glass block until it reaches the surface RS, [1]

(c) label, at X, the angle of incidence with a letter *i* and the angle of refraction with a letter *r*, [2]

(d) draw the path of the ray of light leaving the glass block. [1]

[Total: 5]

2 **(a)** Fig. 6.1 shows a plane mirror reflecting a ray of light.

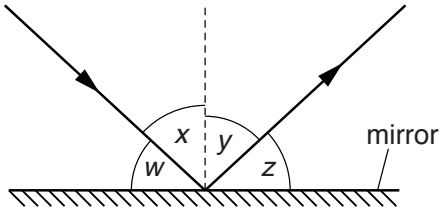

Fig. 6.1

(i) There is a dashed line drawn at right angles to the mirror.

State the name of this line.

.....[1]

(ii) State which angle, *w*, *x*, *y*, or *z*, is the angle of reflection.

.....[1]

(b) Fig. 6.2 shows a ray of white light entering a semi-circular glass block. The ray of light emerges at point R and travels alongside the flat surface.

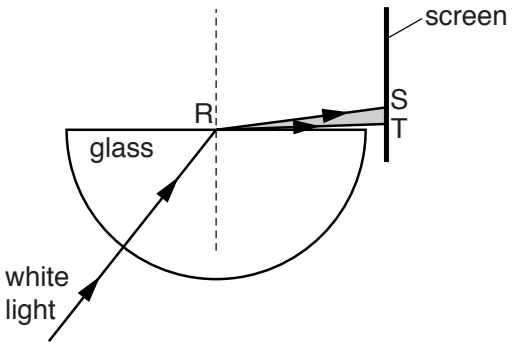

Fig. 6.2

A spectrum of colours can be seen on the screen between S and T.

(i) State the colours in the correct order. One has been done for you.

colour at S ..... red .....

.....

.....

.....

.....

.....

colour at T ..... [1]

(ii) The angle of the ray is changed.

On Fig. 6.3, complete the path of the ray of light. Explain your answer.

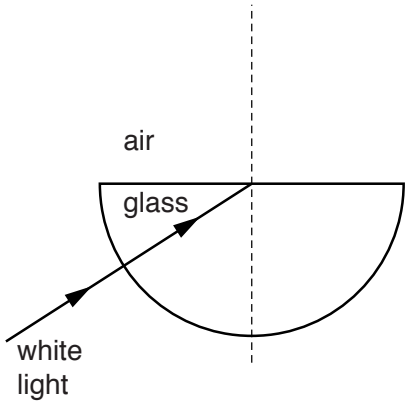

Fig. 6.3

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.....[3]

[Total: 6]

3 Fig. 6.1 shows a glass block ABCD surrounded by air. A ray of red light, PQ, is incident on face CD of the block.

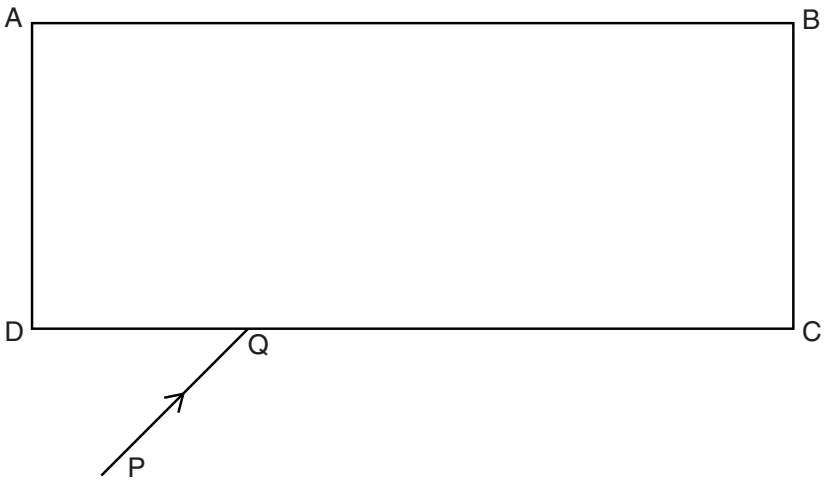

Fig. 6.1

(a) On Fig. 6.1,

(i) draw the normal at Q and the refracted ray inside the block so that it meets face AB,

(ii) draw the ray emerging from face AB of the block and the normal where the ray emerges,

(iii) between the rays and the normals you have drawn, label two equal angles X.

[3]

(b) The angle of incidence of another red ray is 65°. The refractive index of the glass of block ABCD for red light is 1.62.

(i) Calculate the angle of refraction in the glass for this ray.

angle = ... [2]

(ii) The speed of light in air is 3.0×10^8 m/s.

Calculate the speed of the red light in the glass.

speed = ... [2]

(c) For the same angle of incidence, the angle of refraction of red light in glass is greater than the angle of refraction of violet light.

State the term which describes the separation of red and violet refracted rays in glass.

..... [1]

[Total: 8]

4 The refractive index n of glass in air is 1.5.

(a) **(i)** State the equation that relates the speed of light in air v_a, the speed of light in glass v_g and n.

.....[1]

(ii) The speed of light in air is 3.0×10^8 m/s.

Calculate the speed of light in glass.

speed = ...[1]

(b) Light travelling in glass strikes the edge of the glass. Fig. 6.1 shows a ray of light at an angle of 41° to the normal.

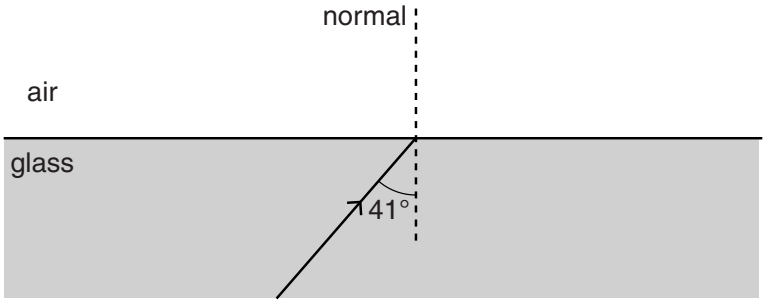

Fig. 6.1

(i) The light passes from the glass into the air.

Calculate the angle that the ray makes with the normal in the air.

angle = ...[2]

(ii) State what happens to light that strikes the edge of the glass at an angle to the normal much larger than 41°.

.....[1]

(c) Describe one example of how optical fibres are used in medicine.

.....

.....

.....

.....[2]

[Total: 7]

5 **(a)** The refractive index of a type of glass is 1.6.

Calculate the critical angle for light in this type of glass.

critical angle = ...[3]

(b) A waterproof laser is immersed in water. Fig. 7.1 shows the laser shining light up towards the horizontal surface of the water.

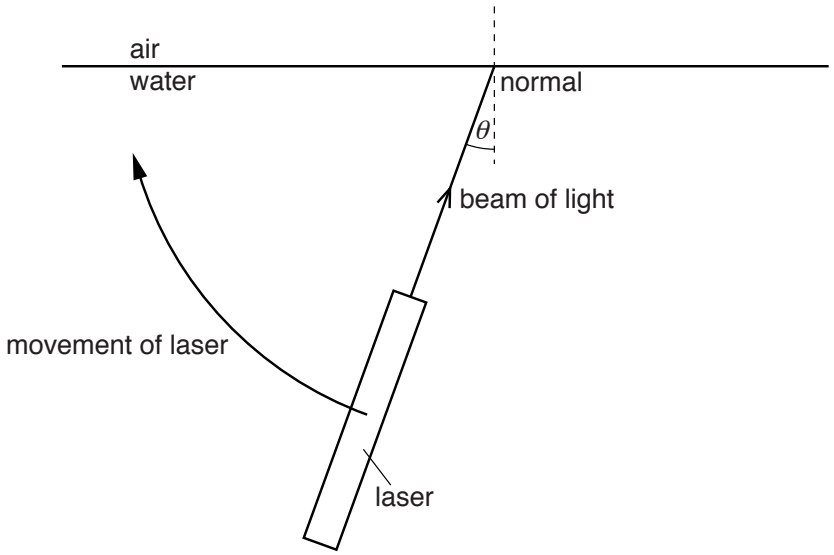

Fig. 7.1

Initially, the angle θ is much less than the critical angle for this light in water.

The laser moves and θ gradually increases until it is much greater than the critical angle.

Describe, for different angles of the laser, what happens to the light beam after it hits the surface.

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.....

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.....[4]

[Total: 7]

6 **(a)** Fig. 6.1 shows a ray of light incident on the surface of a glass block.

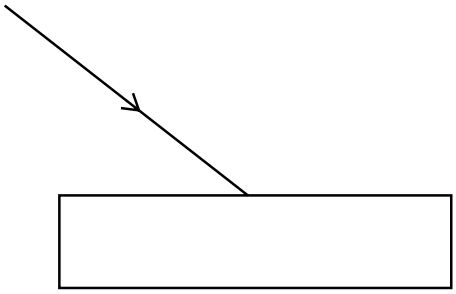

Fig. 6.1

On Fig. 6.1, accurately draw the reflected ray. [2]

(b) Fig. 6.2 shows a ray of light incident on a glass prism.

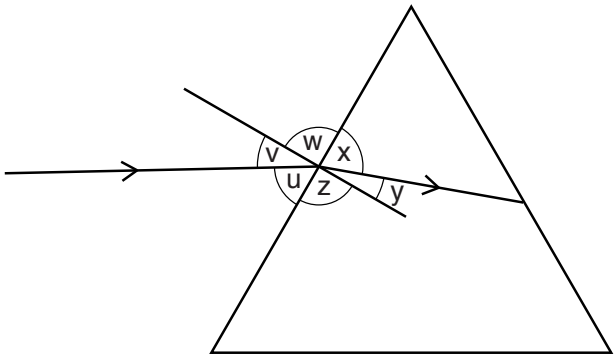

Fig. 6.2

Put **one tick only** in each line of the table to indicate which of the angles labelled in Fig. 6.2 are the angle of incidence and the angle of refraction.

	u	v	w	x	y	z
angle of incidence						
angle of refraction						

[2]

(c) The refractive index of water is 1.33. A ray of light passes from water into air. The angle of incidence at the water-air interface is 30°.

Calculate the angle of refraction.

angle of refraction = ... [3]

(d) Fig. 6.3 shows rays of violet and red light incident on a prism. The dashed line shows the path taken by the ray of violet light in the prism.

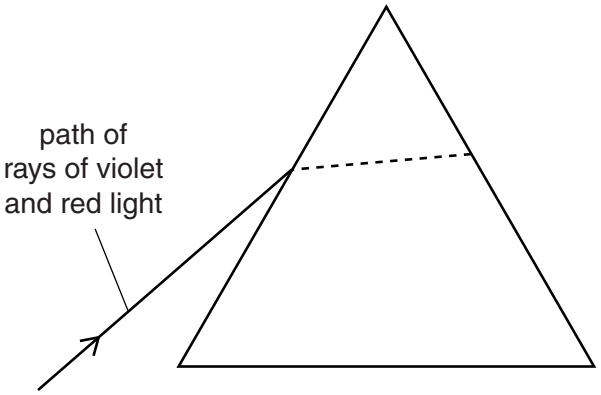

Fig. 6.3

On Fig. 6.3, draw and label the path that the ray of red light takes in the prism. A calculation is not required. [2]

[Total: 9]

7 Fig. 11.1 shows part of the path of a ray of light PQ travelling in an optical fibre.

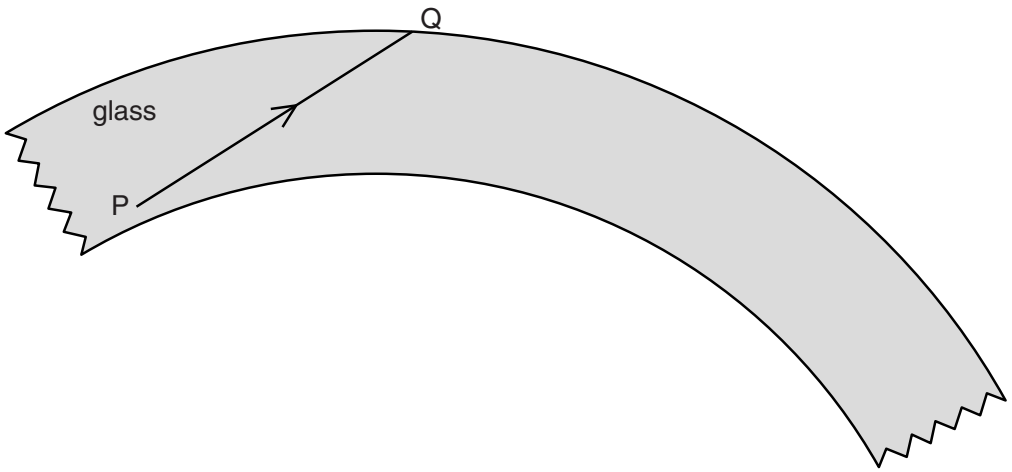

Fig. 11.1

(a) On Fig. 11.1, carefully complete the path of the ray of light, until it leaves this section of the optical fibre. [2]

(b) The material of an optical fibre has a refractive index of 1.52.

Calculate the critical angle.

critical angle = ...[2]

(c) **(i)** State what sort of reflection takes place within an optical fibre.

..... [1]

(ii) Explain your answer.

.....

..... [1]

[Total: 6]

8 Light enters a glass fibre from air at an angle of incidence of 62°. The angle of refraction in the glass is 36°.

(a) The speed of light in air is 3.0×10^8 m/s.

Determine the speed of light in the glass fibre.

speed = ... [4]

(b) Describe how glass fibres are used in communications technology.

.....

.....

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.....[3]

[Total: 7]

9 **(a)** Fig. 6.1 shows two rays from a point object P incident on a water surface.

An observer sees the image of P produced by reflection at the surface of the water.

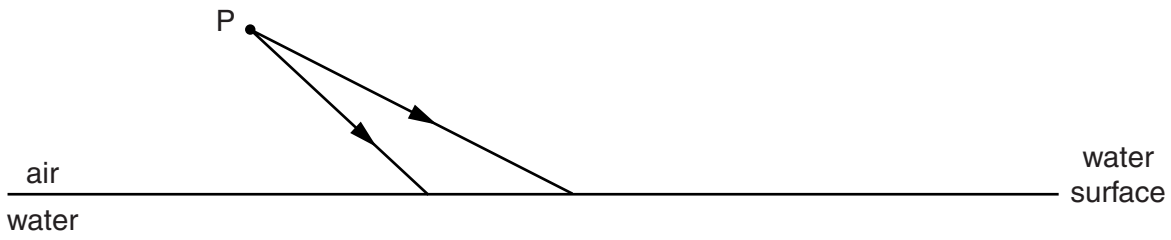

Fig. 6.1

On Fig. 6.1, draw the reflected rays and complete the diagram to locate the position of the image. Label the position of the image I. [2]

(b) Fig. 6.2 shows two rays from a point object Q incident on another water surface.

An observer sees the image of Q produced by refraction at the surface of the water.

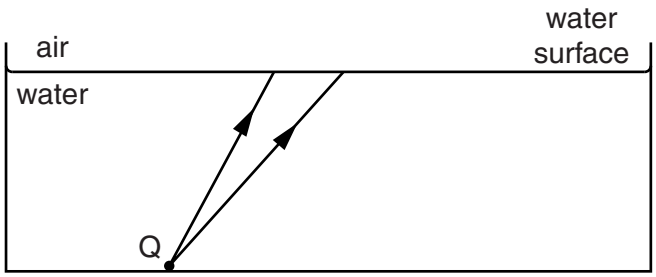

Fig. 6.2

On Fig. 6.2, draw possible refracted rays and complete the diagram to locate a possible position of the image. Label the position of the image J.
You do not need to calculate any angles. [2]

(c) The refractive index of water is 1.33.

Calculate the critical angle.

critical angle = ...[2]

(d) Describe, with a diagram, a medical use of optical fibres.

.....

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.....[3]

[Total: 9]

10 A ray of light from a laser passes from air into a clear, semi-circular, plastic block. Fig. 7.1 shows the ray entering the block.

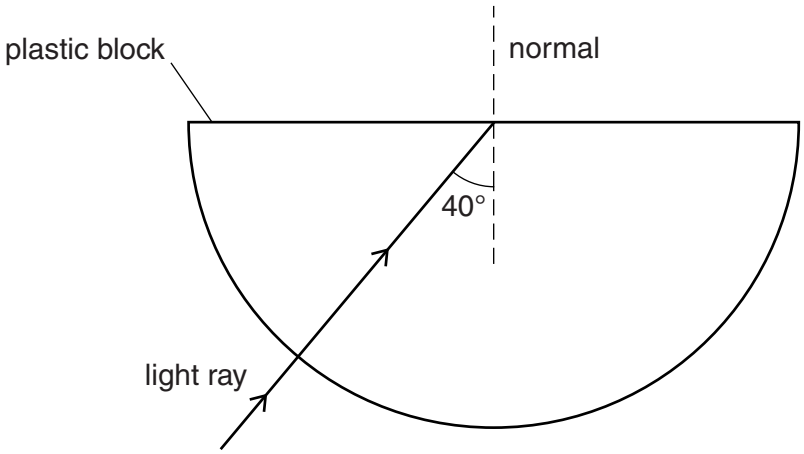

Fig. 7.1

The ray continues in the same direction and meets the middle of the opposite surface at an angle of 40° to the normal. The refractive index of the plastic is 1.5.

(a) The ray continues into the air.

Calculate the angle between the normal and the path taken by the light after it leaves the block.

angle = ... [3]

(b) The frequency of the light produced by this laser is 3.8×10^{14} Hz and its wavelength in the plastic block is 5.3×10^{-7} m (0.000 53 mm).

Calculate

(i) the speed of light in this plastic,

speed = ... [2]

(ii) the speed of light in air.

speed = ... [2]

(c) Explain why the ray does not change direction as it enters the plastic block.

.....

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.....[2]

[Total: 9]