1 A laser produces a ray of blue light of wavelength 4.0×10^{-7} m (0.000 000 40 m).

(a) **(i)** State the speed of light in a vacuum.

speed = ... [1]

(ii) Calculate the frequency of the light produced by the laser.

frequency = ... [2]

(b) The ray of blue light passes from air into a glass block. Fig. 6.1 shows the ray making an angle of 35° with the side of the block.

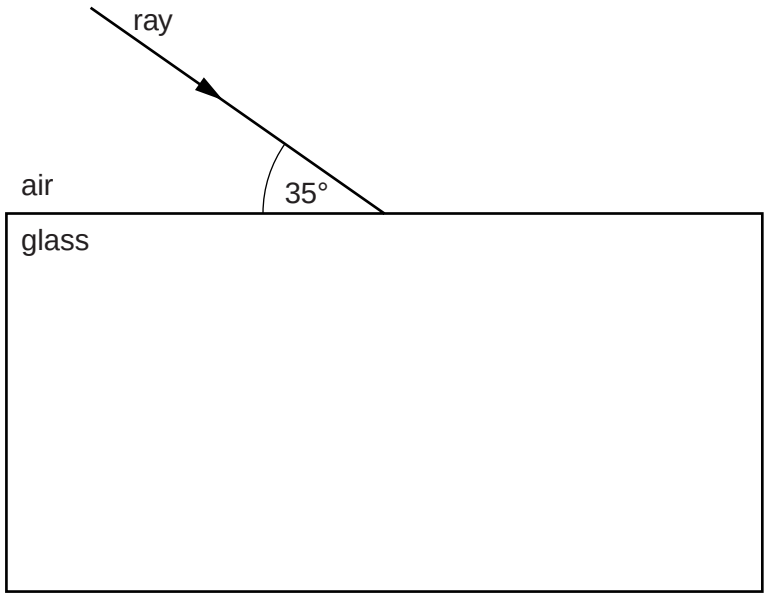

Fig. 6.1

(i) State the angle of incidence of the ray of blue light on the glass.

angle of incidence = ... [1]

(ii) Glass has a refractive index of 1.5.

Calculate the angle of refraction of the light in the glass.

angle of refraction = ... [2]

[Total: 6]

2 **(a)** The speed of light in air is known to be 3.0×10^8 m/s.

Outline how you would use a refraction experiment to deduce the speed of light in glass. You may draw a diagram if it helps to clarify your answer.

.....

.....

.....

.....

.....

.....[4]

(b) A tsunami is a giant water wave. It may be caused by an earthquake below the ocean.

Waves from a certain tsunami have a wavelength of 1.9×10^5 m and a speed of 240 m/s.

(i) Calculate the frequency of the tsunami waves.

frequency = ...[2]

(ii) The shock wave from the earthquake travels at 2.5×10^3 m/s.

The centre of the earthquake is 6.0×10^5 m from the coast of a country.

Calculate how much warning of the arrival of the tsunami at the coast is given by the earth tremor felt at the coast.

warning time = ...[4]

[Total: 10]

3 During a thunderstorm, thunder and lightning are produced at the same time.

(a) A person is some distance away from the storm.

Explain why the person sees the lightning before hearing the thunder.

.....

.....

..... [1]

(b) A scientist in a laboratory made the following measurements during a thunderstorm.

time from start of storm / minutes	0.0	2.0	4.0	6.0	8.0	10.0
time between seeing lightning and hearing thunder / s	3.6	2.4	1.6	2.4	3.5	4.4

Fig. 7.1

(i) How many minutes after the storm started did it reach its closest point to the laboratory?

..... [1]

(ii) How can you tell that the storm was never immediately over the laboratory?

..... [1]

(iii) When the storm started, it was immediately above a village 1200 m from the laboratory.

Using this information and information from Fig. 7.1, calculate the speed of sound.

speed of sound = ... [2]

(iv) State the assumption you made when you calculated your answer to **(b)(iii)**.

..... [1]

(c) Some waves are longitudinal; some waves are transverse.

Some waves are electromagnetic; some waves are mechanical.

Put ticks (✓) in the table below to indicate which of these descriptions apply to the light waves of the lightning and the sound waves of the thunder.

	light waves	sound waves
longitudinal		
transverse		
electromagnetic		
mechanical		

[3]

[Total: 9]

4 **(a)** A small object S is dipped repeatedly into water near a flat reflecting surface.

Fig. 10.1 gives an instantaneous view from above of the position of part of the waves produced.

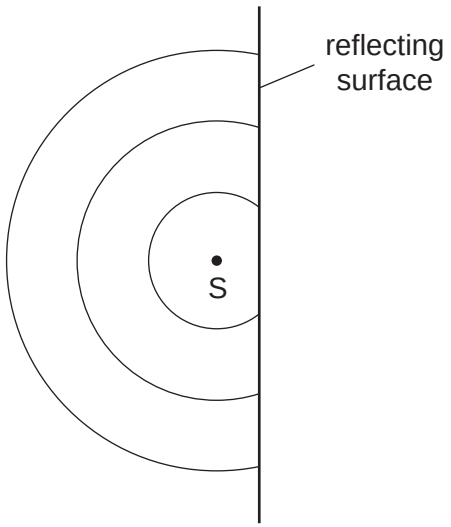

Fig. 10.1

On Fig. 10.1,

(i) put a clear dot at the point from which the reflected waves appear to come (label the dot R),

(ii) draw the reflected portion of each of the three waves shown. [3]

(b) Fig. 10.2 shows a small object P in front of a plane mirror M.

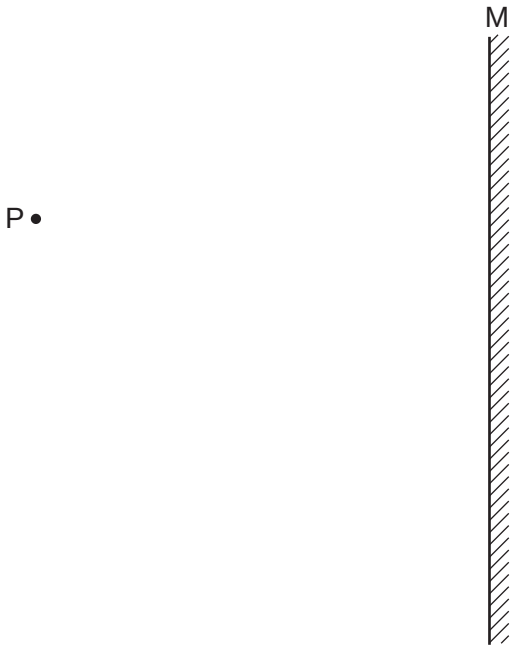

Fig. 10.2

On Fig. 10.2, carefully draw two rays that show how the mirror forms the image of object P. Label the image I. [3]

[Total: 6]

5 Fig. 6.1 shows an optical fibre. XY is a ray of light passing along the fibre.

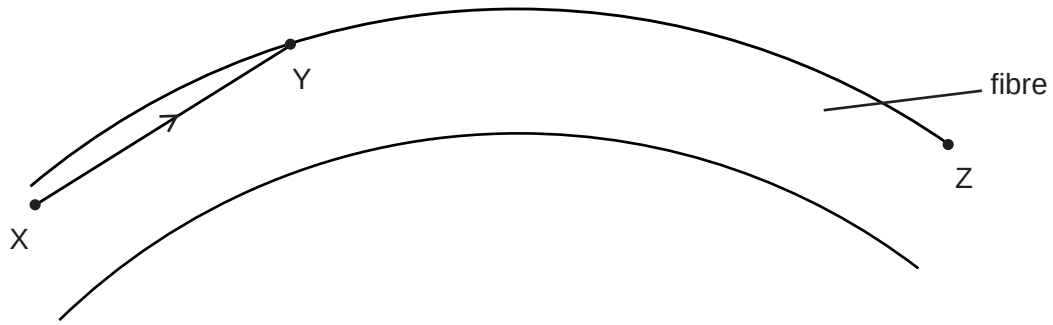

Fig. 6.1

(a) On Fig. 6.1, continue the ray XY until it passes Z. [1]

(b) Explain why the ray does **not** leave the fibre at Y.

.....

.....

.....[2]

(c) The light in the optical fibre has a wavelength of 3.2×10^{-7} m and is travelling at a speed of 1.9×10^{8} m/s.

(i) Calculate the frequency of the light.

frequency = ……...

(ii) The speed of light in air is 3.0×10^{8} m/s.
Calculate the refractive index of the material from which the fibre is made.

refractive index = ……...
[4]

[Total : 7]

6 Fig. 6.1 shows wavefronts of light crossing the edge of a glass block from air into glass.

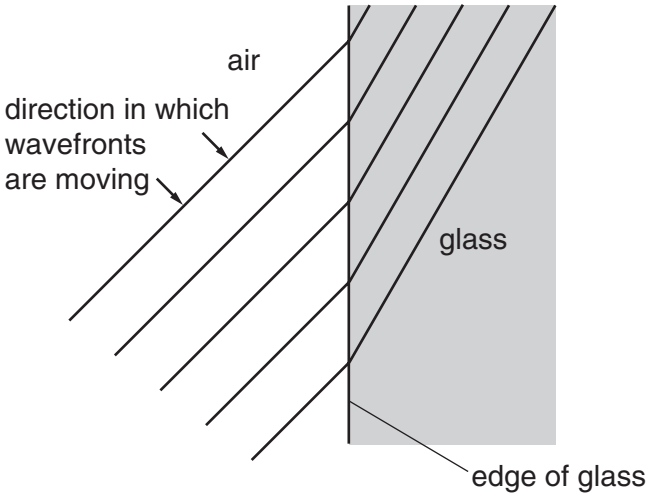

Fig. 6.1

(a) On Fig. 6.1

(i) draw in an incident ray, a normal and a refracted ray that meet at the same point on the edge of the glass block,

(ii) label the angle of incidence and the angle of refraction,

(iii) measure the two angles and record their values.

angle of incidence = ...

angle of refraction = ...

[4]

(b) Calculate the refractive index of the glass.

refractive index = ...[3]

[Total : 7]

7 In a thunderstorm, both light and sound waves are generated at the same time.

(a) How fast does the light travel towards an observer?

speed = ... [1]

(b) Explain why the sound waves always reach the observer after the light waves.

.....[1]

(c) The speed of sound waves in air may be determined by experiment using a source that generates light waves and sound waves at the same time.

(i) Draw a labelled diagram of the arrangement of suitable apparatus for the experiment.

(ii) State the readings you would take.

.....

.....

.....

(iii) Explain how you would calculate the speed of sound in air from your readings.

.....

.....
[4]

[Total : 6]

8 Fig. 7.1 is drawn to full scale. The focal length of the lens is 5.0 cm.

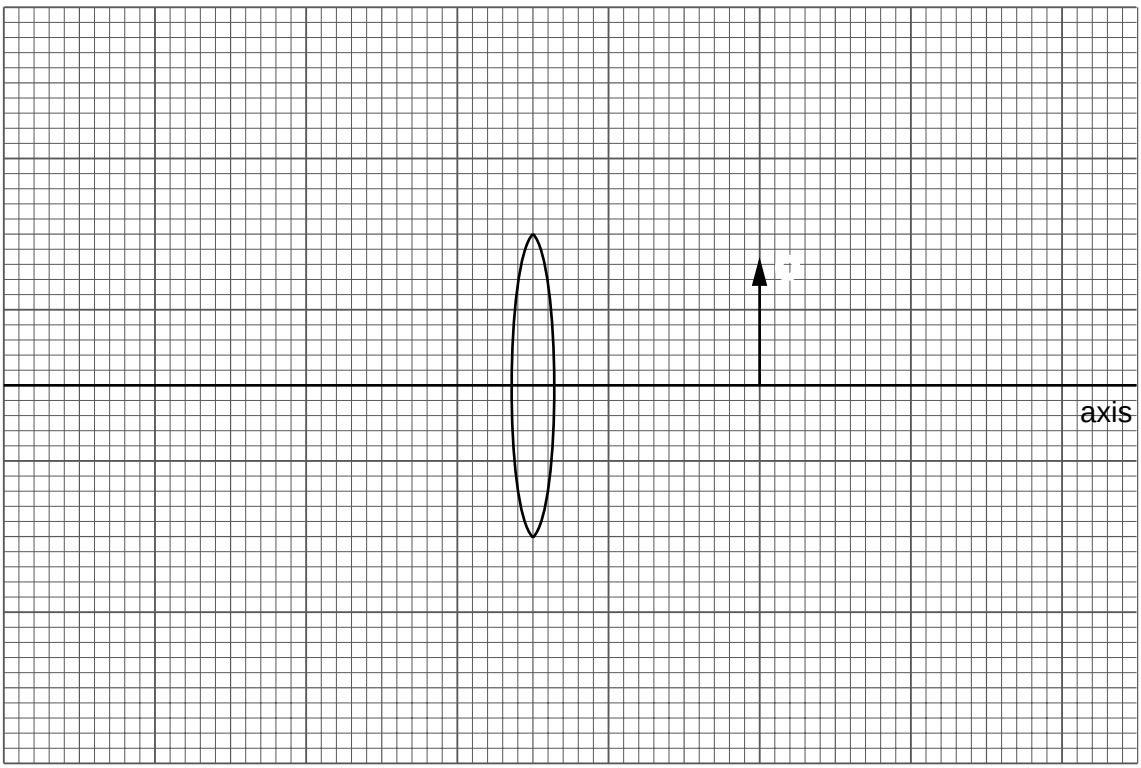

Fig. 7.1

(a) On Fig. 7.1, mark each principal focus of the lens with a dot and the letter F. [2]

(b) On Fig. 7.1, draw **two** rays from the tip of the object O that appear to pass through the tip of the image. [2]

(c) On Fig. 7.1, draw the image and label it with the letter I. [1]

(d) Explain why the base of the image lies on the axis.

.....

..... [1]

(e) State a practical use of a convex lens when used as shown in Fig. 7.1.

..... [1]

[Total : 7]

9 **(a)** Fig. 6.1 shows the results of an experiment to find the critical angle for light in a semi-circular glass block.

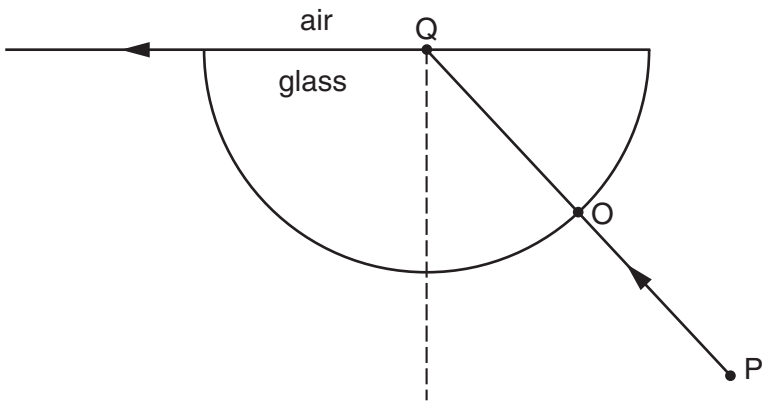

Fig. 6.1

The ray of light PO hits the glass at O at an angle of incidence of 0°.
Q is the centre of the straight side of the block.

(i) Measure the critical angle of the glass from Fig. 6.1.

critical angle = ...

(ii) Explain what is meant by the *critical angle* of the light in the glass.

.....

.....

.....

[3]

(b) Fig. 6.2 shows another ray passing through the same block.

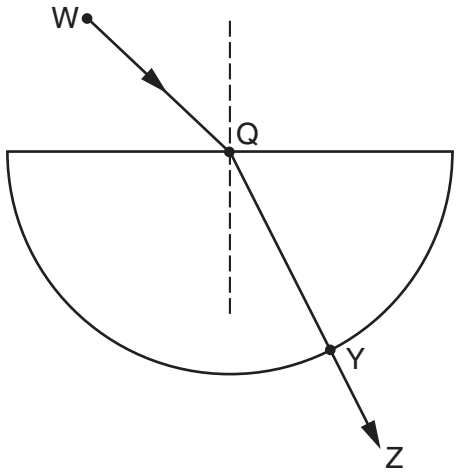

Fig. 6.2

The speed of the light between W and Q is 3.0×10^8 m/s. The speed of the light between Q and Y is 2.0×10^8 m/s.

(i) State the speed of the light between Y and Z.

speed = ...

(ii) Write down an expression, in terms of the speeds of the light, that may be used to find the refractive index of the glass. Determine the value of the refractive index.

refractive index = ...

(iii) Explain why there is no change of direction of ray QY as it passes out of the glass.

.....

(iv) What happens to the wavelength of the light as it passes out of the glass?

.....

[5]

[Total : 8]