5 Ultrasound has a number of different uses in medicine.

Which of the following is the main reason why ultrasound is not used to perform scans of the chest and lungs?

- ☒ **A** The air in the lungs causes most of the ultrasound to be reflected back.
- ☒ **B** The duration of the pulses of ultrasound limits the amount of detail that can be seen.
- ☒ **C** The wavelength of the ultrasound is too long.
- ☒ **D** Ultrasound can damage the lungs.

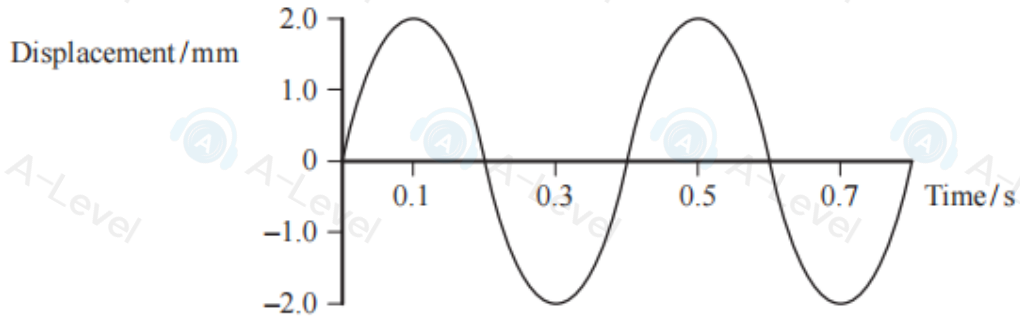
(Total for Question 5 = 1 mark)

9 The wavelength of a progressive wave is defined as the distance between adjacent points on the wave which

- ☒ **A** have the same displacement.
- ☒ **B** have the same amplitude.
- ☒ **C** are in phase.
- ☒ **D** are in antiphase.

(Total for Question 9 = 1 mark)

2 A wave is travelling across the surface of a tank of water. The graph shows how the displacement of the water at one position on the surface varies with time.



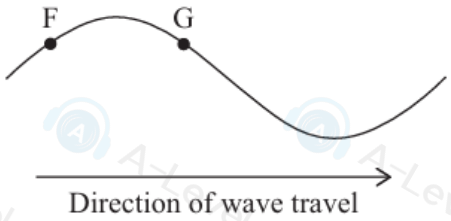
Which property of the wave **cannot** be determined using only the information from this graph?

- ☒ **A** amplitude
- ☒ **B** frequency
- ☒ **C** time period
- ☒ **D** wavelength

(Total for Question 2 = 1 mark)

DO NOT WRITE IN THIS AREA

9 A wave is moving along a length of string in the direction shown.



F and G are two points on the string.

Which row of the table describes the movement of F and G as one complete wave passes?

	F	G
☒ **A**	Down then up	Down then up
☒ **B**	Down then up	Up then down
☒ **C**	Down, then up, then down	Up, then down, then up
☒ **D**	Up, then down, then up	Down, then up, then down

(Total for Question 9 = 1 mark)

7 Two waves are coherent.

Which of the following **must** be true for the two waves?

☒ **A** They are in antiphase with each other.

☒ **B** They are in phase with each other.

☒ **C** They have the same amplitude.

☒ **D** They have the same frequency.

(Total for Question 7 = 1 mark)

DO NOT WRITE IN THIS AREA

9 Two waves from the same source travel along different paths and then meet at a point P. The phase difference between the waves at P is 1.5π radians.

Which of the following is a possible path difference that could result in this phase difference being produced at P?

☐ **A** $\frac{3\lambda}{2}$

☐ **B** $\frac{7\lambda}{4}$

☐ **C** 3λ

☐ **D** $\frac{7\lambda}{2}$

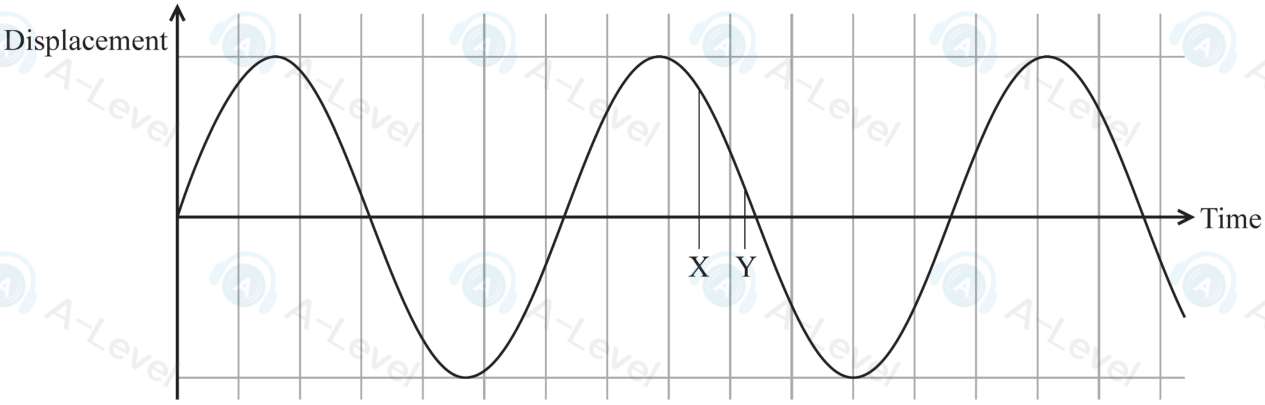
(Total for Question 9 = 1 mark)

1 Two waves, of wavelength λ, from a single source diverge and then meet again. Which of the following situations would cause constructive interference?

- ☒ **A** a path difference of $\frac{\lambda}{2}$
- ☒ **B** a path difference of λ
- ☒ **C** a phase difference of $\frac{\pi}{2}$
- ☒ **D** a phase difference of π

(Total for Question 1 = 1 mark)

6 A displacement-time graph for a particular point on a transverse wave is shown. Two times are marked X and Y.



Which of the following represents the change in displacement of this point between times X and Y?

☒ **A** ☒ **B** ☒ **C** ☒ **D**

(Total for Question 6 = 1 mark)

2 Two waves from the same source arrive at a point with a path difference of $\frac{3\lambda}{8}$, where λ is the wavelength.

Which of the following is the phase difference of the waves at this point?

- ☒ **A** 34°
- ☒ **B** 68°
- ☒ **C** 135°
- ☒ **D** 270°

(Total for Question 2 = 1 mark)

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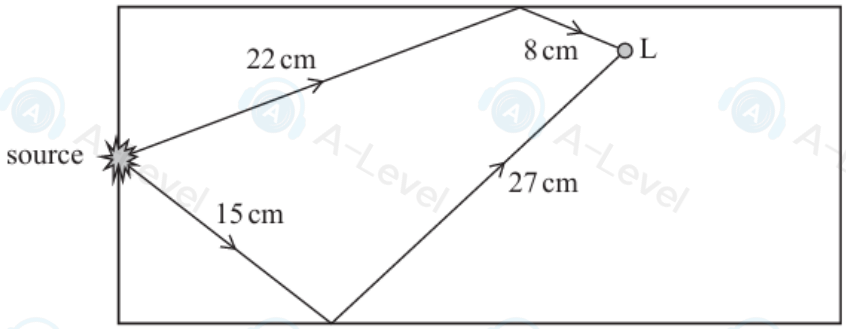
DO NOT WRITE IN THIS AREA

7 A microwave oven has a source that emits microwaves in all directions into the oven. The diagram shows the paths of two microwave rays that meet at point L as shown.



The interference between the waves following these two paths could cause heating effects at L depending on the wavelength of the microwaves.

Which row of the table is possible at point L?

	Heating effect at L	Wavelength / cm
☒ **A**	maximum heating	24
☒ **B**	maximum heating	18
☒ **C**	no heating	24
☒ **D**	no heating	18

DO NOT WRITE IN THIS AREA

3 Ultrasound can be used to investigate organs inside the human body.

Which of the following statements about ultrasound is correct?

☒ **A** All of the ultrasound is reflected at a boundary between different tissues.

☒ **B** Ultrasound travels faster in air than inside the body.

☒ **C** Ultrasound with a greater wavelength gives an image with a higher resolution.

☒ **D** Ultrasound with a shorter pulse duration gives an image with a higher resolution.

(Total for Question 3 = 1 mark)

3 A person hears the sound from the siren of an approaching police car.

Which of the following properties of the sound wave does **not** change if the car stops moving?

☒ **A** frequency

☒ **B** time period

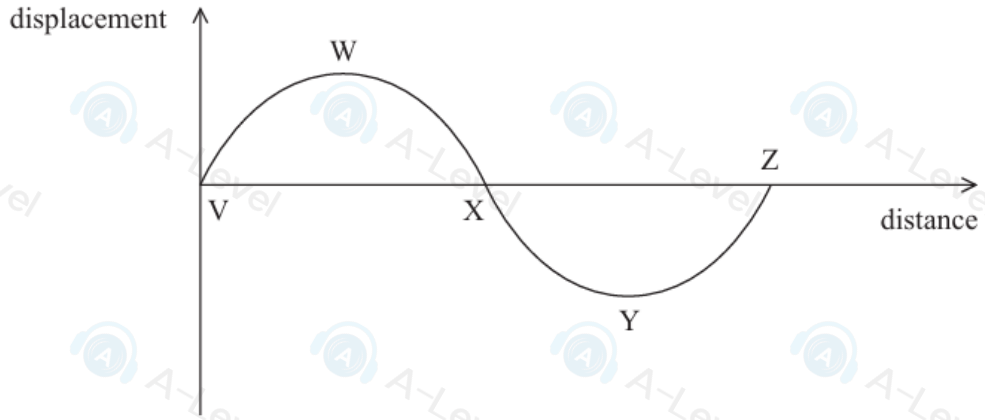
☒ **C** velocity

☒ **D** wavelength

(Total for Question 3 = 1 mark)

DO NOT WRITE IN THIS AREA

10 A sound wave travels through air. The diagram represents the displacement of air particles along the wave at an instant in time.



There is a compression at position V.

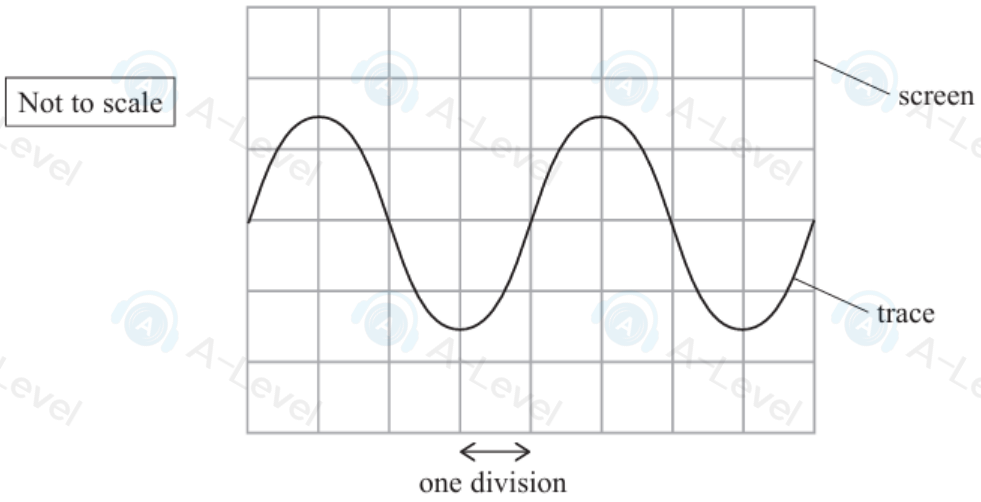
At which position is there also a compression?

- ☒ **A** W
- ☒ **B** X
- ☒ **C** Y
- ☒ **D** Z

(Total for Question 10 = 1 mark)

7 A microphone is attached to an oscilloscope. The microphone detects a sound.

The trace displayed on the oscilloscope screen is shown.



One horizontal division represents a time of 0.015 s.

Which of the following expressions gives the frequency of the sound in Hz?

☒ **A** 4×0.015

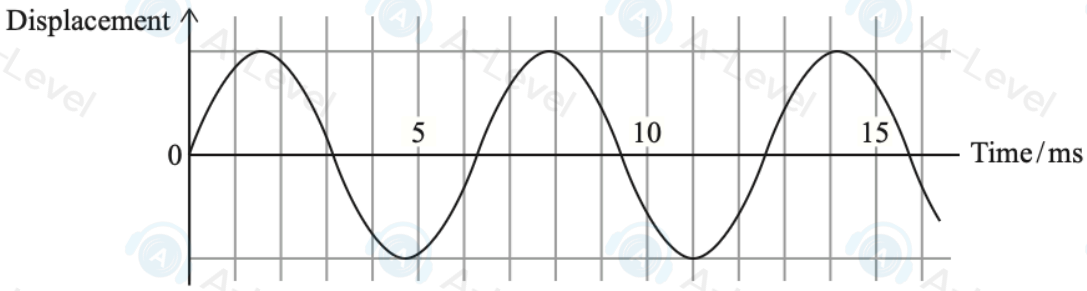
☒ **B** 2×0.015

☒ **C** $\frac{1}{2 \times 0.015}$

☒ **D** $\frac{1}{4 \times 0.015}$

(Total for Question 7 = 1 mark)

5 The graph shows how displacement varies with time for a particular point as a wave passes.



Which of the following statements is **not** correct?

☒ **A** The time period can be determined directly from the graph.

☒ **B** The wavelength can be determined directly from the graph.

☒ **C** The wave could be longitudinal.

☒ **D** The wave could be transverse.

(Total for Question 5 = 1 mark)

18 The photograph shows a typical lightning strike which occurs as a result of an electrical discharge through the atmosphere in a narrow channel between a cloud and the ground.

(Source: © Joshua Lewis/EyeEm/Getty Images)

The high current in a lightning strike heats the air sufficiently to cause rapid expansion; the resulting shock wave is heard as thunder.

(a) A teacher says that a lightning strike taking place 1 km away from the observer will result in a time of 3 s between seeing the lightning and hearing the thunder.

Determine whether the teacher is correct.

speed of sound in air = 340 m s^{-1}

(3)

(b) The following data was collected for one particular lightning strike:

distance between cloud and ground = 400 m
current = 25 000 A
duration of lightning strike = 30 μs
potential difference between cloud and ground = 1.2×10^9 V
diameter of lightning channel = 5.0 cm

(i) Calculate the total charge transferred during the lightning strike.

(2)

Total charge transferred = ...

(ii) Calculate the power dissipated by the lightning strike.

(2)

Power dissipated = ...

(iii) Show that the resistivity of the air in the lightning channel is about 0.2 Ω m.

(3)

(iv) The accepted value for the resistivity of air is $10^{16}\,\Omega$m.

Suggest why the value calculated from the data is so much less than the accepted value.

(1)

(c) Air consists mainly of nitrogen and oxygen molecules. Analysis of the light produced during a lightning strike shows a weak line spectrum.

(i) Explain the process by which nitrogen atoms produce a line spectrum.

(4)

(ii) State why the line spectrum produced by oxygen atoms in the air would be different from the line spectrum produced by nitrogen atoms.

(1)

(Total for Question 18 = 16 marks)

19 A loudspeaker produces a sound wave in air.

(a) Diagram 1 shows air molecules before the sound wave passes.

Diagram 1

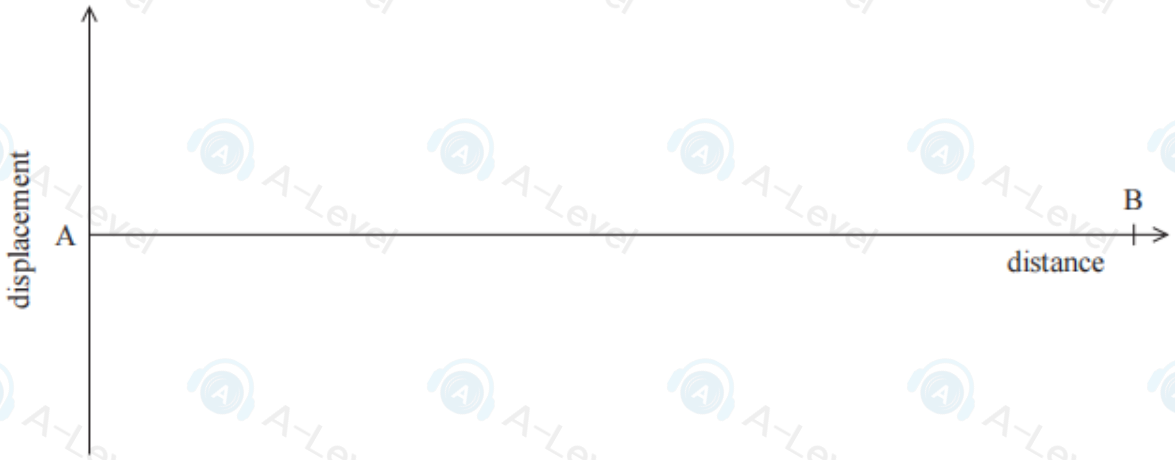
At a particular instant as the sound wave passes, the air molecules are displaced as shown in Diagram 2.

Diagram 2

(i) Label a point on Diagram 2 where the pressure of the air is a minimum.

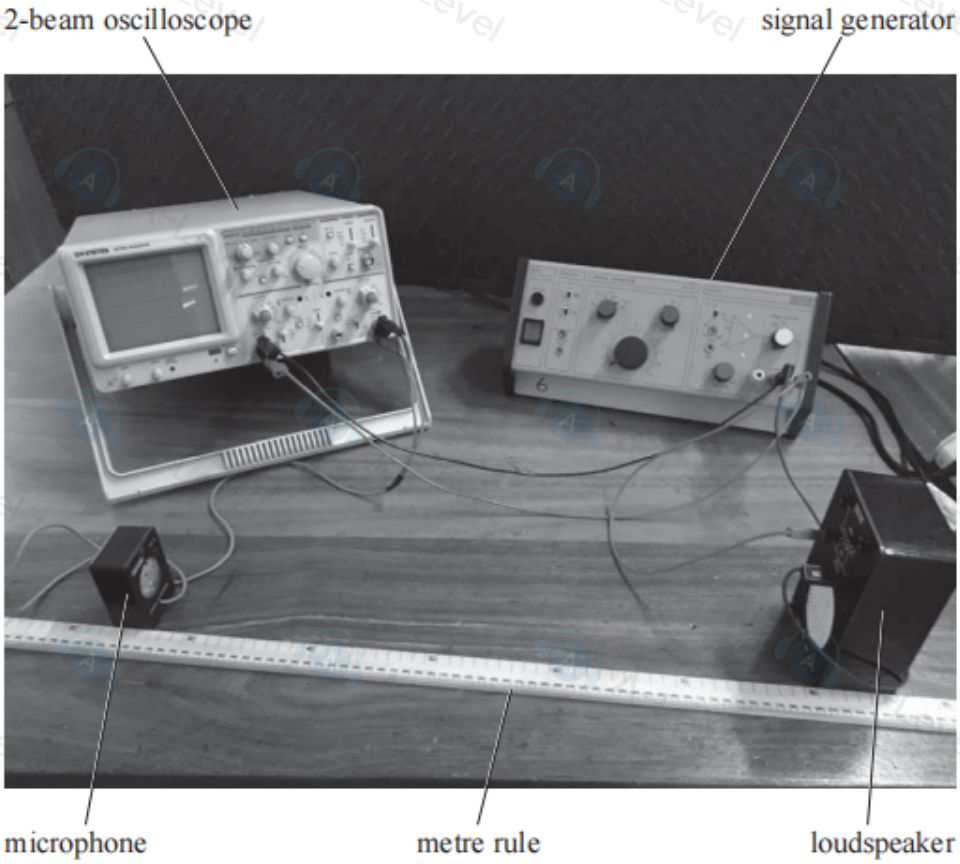
(1)

(ii) Sketch a graph of displacement against distance for the air particles between A and B at this instant on the axes below.



(2)

(b) The speed of sound can be determined using the apparatus shown.



When the loudspeaker is switched on, two traces are produced on the oscilloscope, one directly from the signal generator and the other from the microphone.

(i) Describe how a value for the speed of sound in air can be determined.

(5)

(ii) Describe how the oscilloscope display can be used to demonstrate that the two traces have the same frequency.

(2)

(iii) A frequency of 15.0 kHz was used. A student suggested that the experiment would give a more accurate result for the speed of sound if a frequency of 4.0 kHz was used.

Evaluate the student's suggestion. You should use a calculation in your answer.

speed of sound in air = 340 $m s^{-1}$

(3)

(Total for Question 19 = 13 marks)

16 The speed of sound in sea water varies with depth as shown in diagram A.

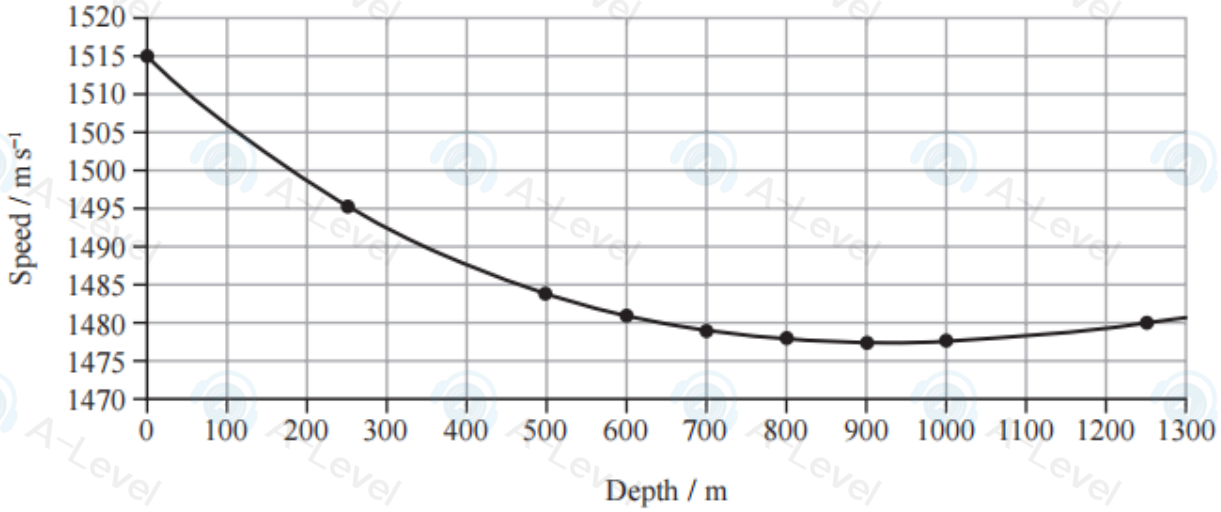


Diagram A

Sound produced at a depth of 900 m initially travels towards the water surface. As the sound approaches a depth of 700 m it changes direction and follows the path shown to the point P in diagram B.

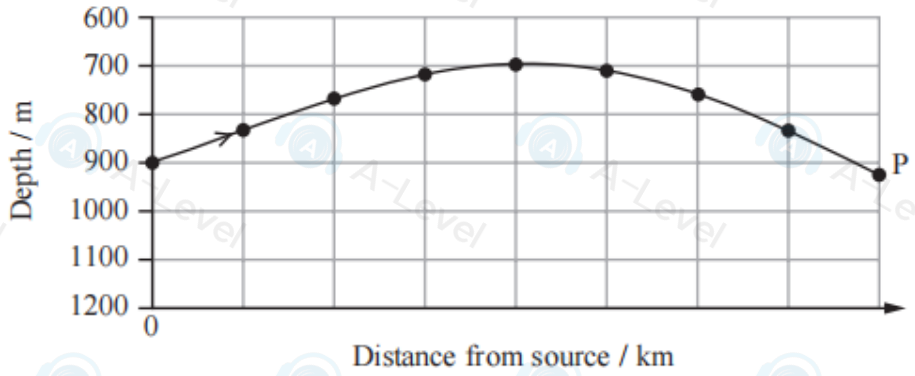


Diagram B

(a) Explain why the sound follows the path shown in diagram B.

Your answer should refer to refraction and diagram A.

(5)

(b) Sound that travels in a straight line from the source to point P takes longer to arrive than sound that travels along the path shown in diagram B.

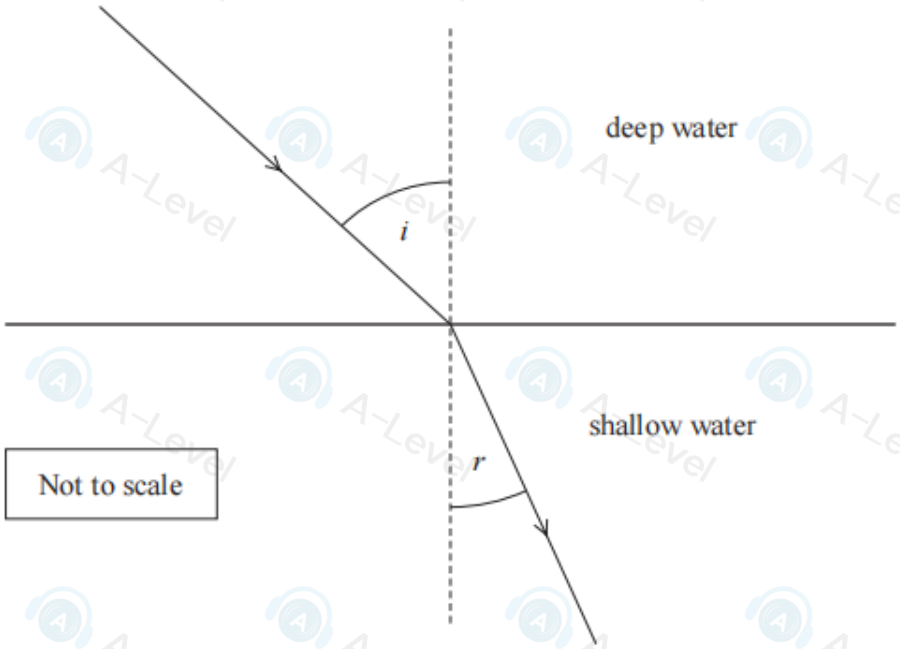
Suggest why.

(2)

(c) Suggest two factors that might cause the speed of sound to vary with the depth of the sea.

(2)

15 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.

(2)

.....

.....

.....

.....

(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°

(5)

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)

14 A student used a diffraction grating to investigate the properties of light.

(a) Light is a transverse wave.

State what is meant by a transverse wave.

(1)

.....

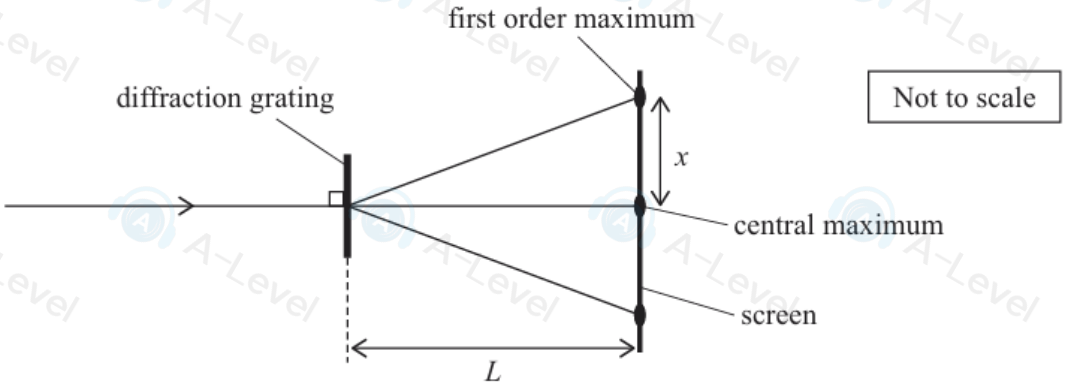
14 A student used a diffraction grating to investigate the properties of light.

(a) Light is a transverse wave.

State what is meant by a transverse wave.

(1)

(b) The student directed monochromatic light of wavelength λ onto the diffraction grating. A series of maxima was produced on a screen a distance L from the diffraction grating, as shown.



The distance between the central maximum and the first order maximum was x.

(i) Calculate the number of lines per mm on the diffraction grating.

$\lambda = 650\,\text{nm}$
$L = 1.30\,\text{m}$
$x = 0.22\,\text{m}$

(4)

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.....

.....

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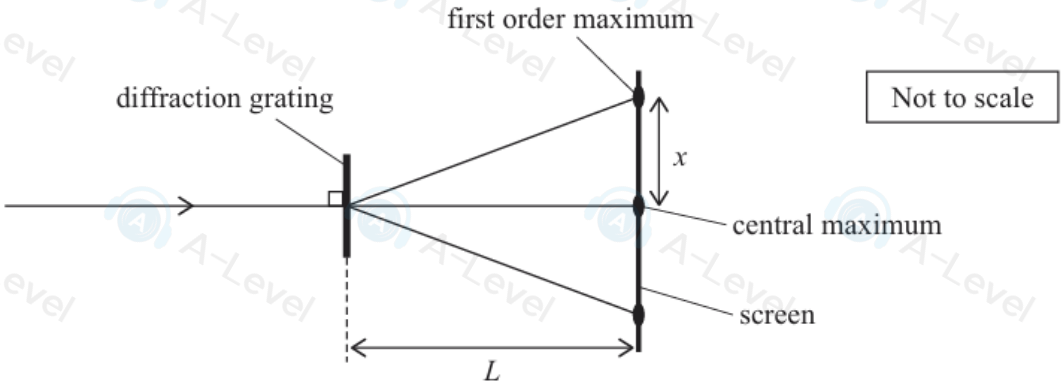

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$L = 1.30\,\text{m}$
$x = 0.22\,\text{m}$

(4)

.....

.....

.....

.....

.....

.....

.....

Number of lines per mm = ...

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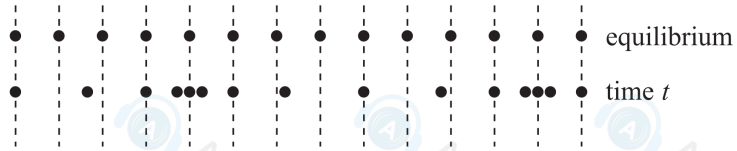
(ii) Explain how a first order maximum is produced on the screen.

(3)

14 A longitudinal wave consists of a series of compressions and rarefactions.

The diagram represents the position of the particles at equilibrium and the position of the particles at a time *t*.



(a) (i) Label with a C on the diagram a position where a compression occurs at time *t*.

(1)

(ii) Take a measurement from the diagram to determine the wavelength of the wave.

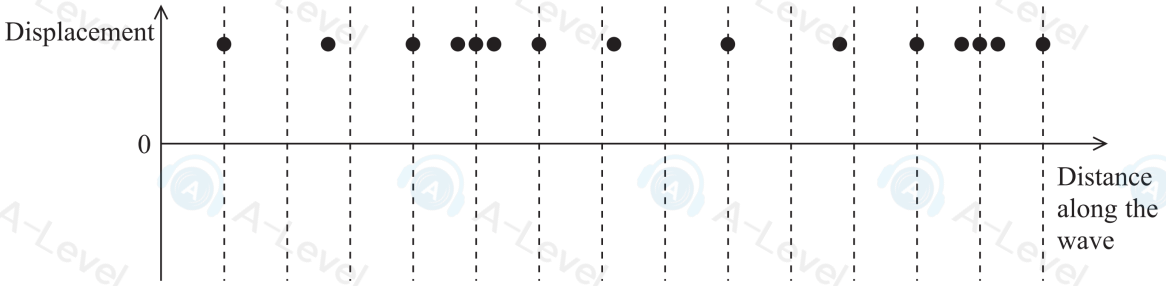
(1)

Wavelength = ...

(b) A longitudinal wave can also be represented as a sine graph of the displacement of the particles against distance along the wave.

On the axes below, draw a displacement-distance graph that corresponds to the longitudinal wave.

(2)



(Total for Question 14 = 4 marks)