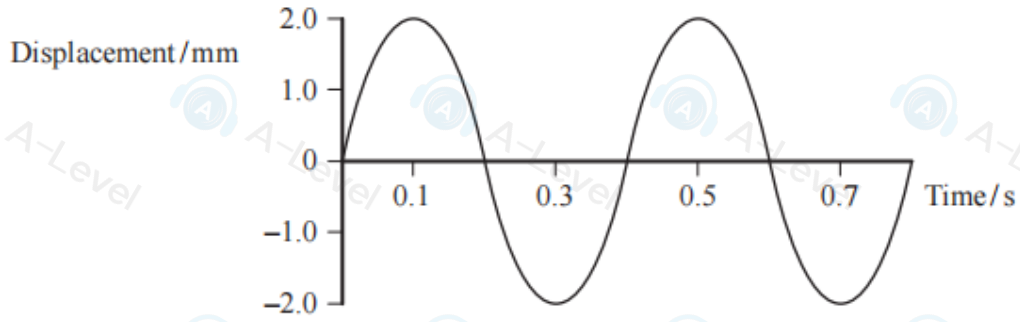
3 A person hears the sound from the siren of an approaching police car.

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)

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)

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)

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.

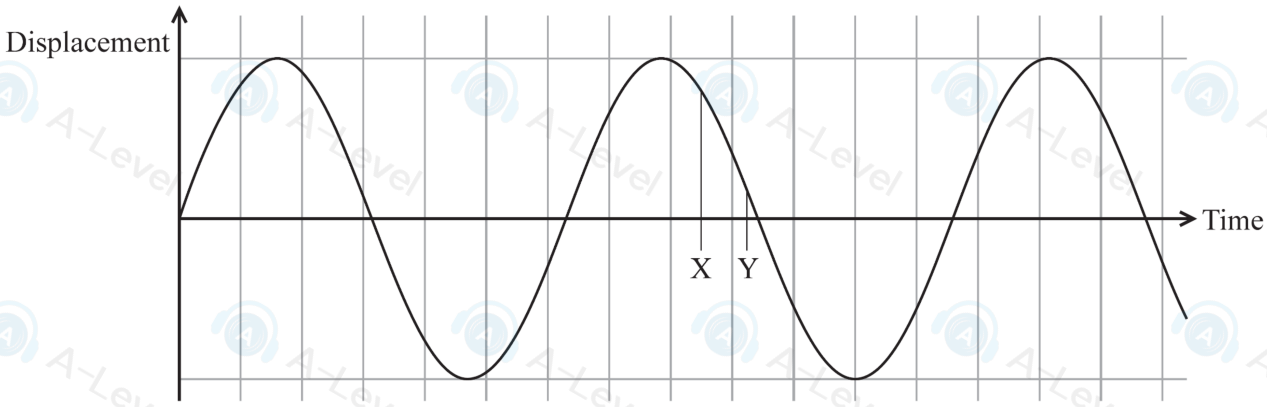
☒ **B** Ultrasound travels faster in air than inside the body.

☒ **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)

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?

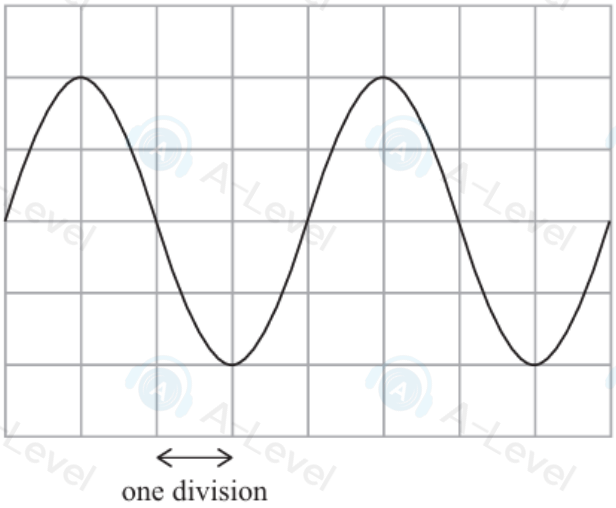
☒ **A** ☒ **B** ☒ **C** ☒ **D**

(Total for Question 6 = 1 mark)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

3 The diagram shows the trace of a sound wave on an oscilloscope.



One horizontal division represents a time of 5 ms.

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

☒ **A** 4×0.005

☒ **B** 2×0.005

☒ **C** $\dfrac{1}{2 \times 0.005}$

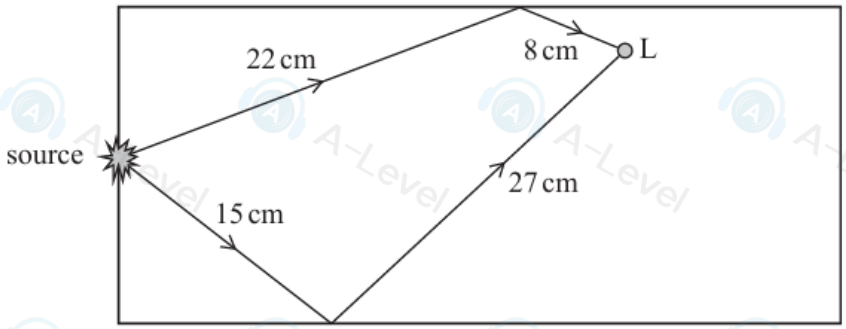
☒ **D** $\dfrac{1}{4 \times 0.005}$

(Total for Question 3 = 1 mark)

DO NOT WRITE IN THIS AREA

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

2 The time period of a wave decreases.

Which of the following properties of the wave increases?

☒ **A** amplitude

☒ **B** frequency

☒ **C** speed

☒ **D** wavelength

(Total for Question 2 = 1 mark)

DO NOT WRITE IN THIS ARE

19 A loudspeaker produces a sound wave in air.

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

Diagram 1

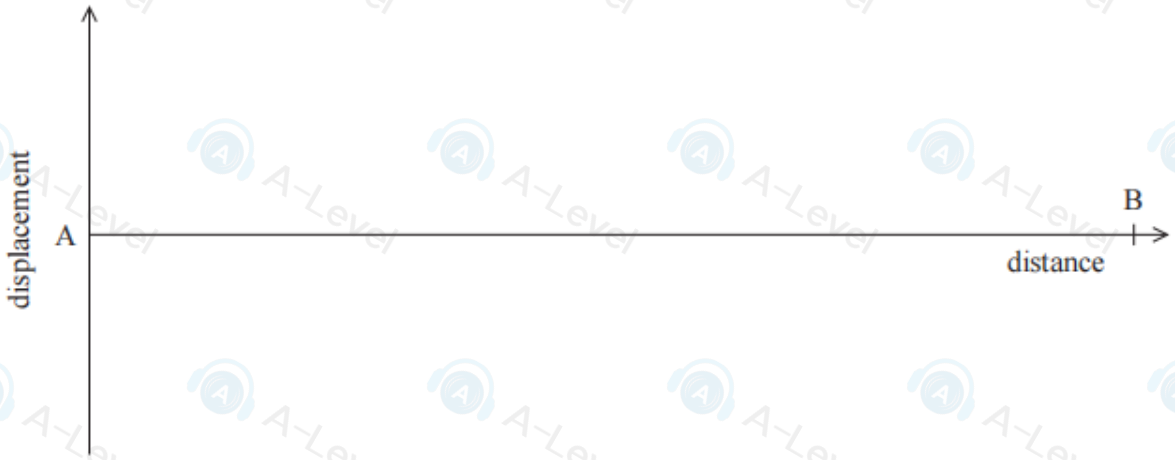
At a particular instant as the sound wave passes, the air molecules are displaced as shown in Diagram 2.

Diagram 2

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

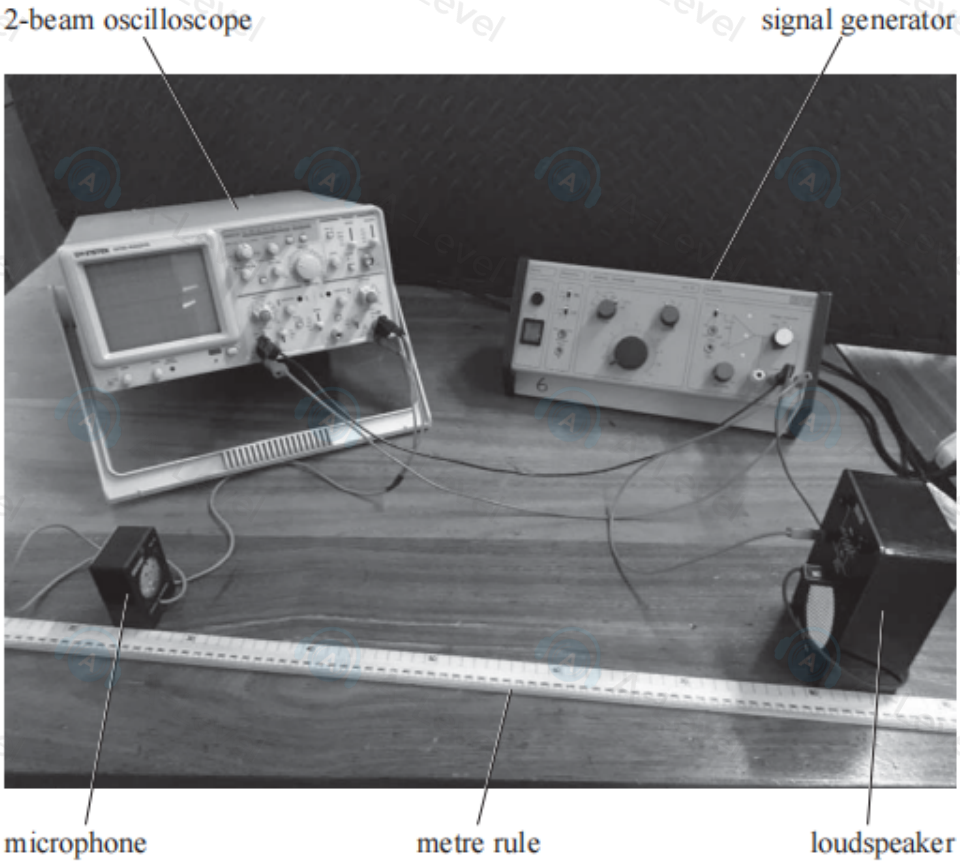
(1)

(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)

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)

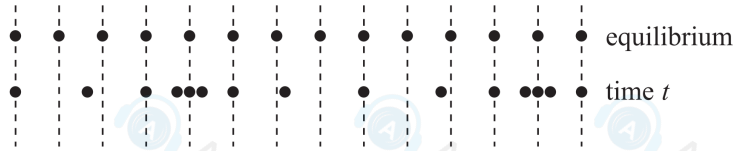
(ii) State why the line spectrum produced by oxygen atoms in the air would be different from the line spectrum produced by nitrogen atoms.

(1)

(Total for Question 18 = 16 marks)

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.

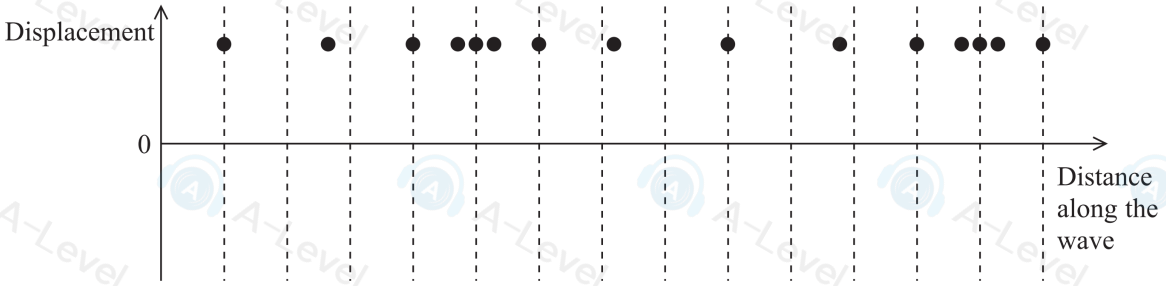
(1)

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.

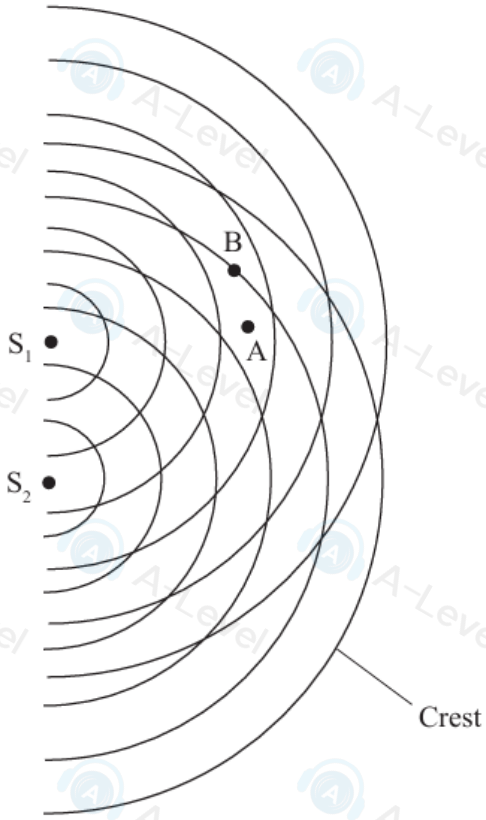
(2)



(Total for Question 14 = 4 marks)

12 A student investigated the superposition of water waves in a ripple tank. There are two sources of waves S_1 and S_2, which are in phase.

The diagram shows the positions of successive crests of each wave at an instant in time.



Explain the type of superposition taking place at position A and at position B on the diagram.

(4)

Position A .....

.....

.....

.....

Position B .....

.....

.....

.....

(Total for Question 12 = 4 marks)

15 In a cinema, sound normally comes from a number of speakers placed at different positions around the room.

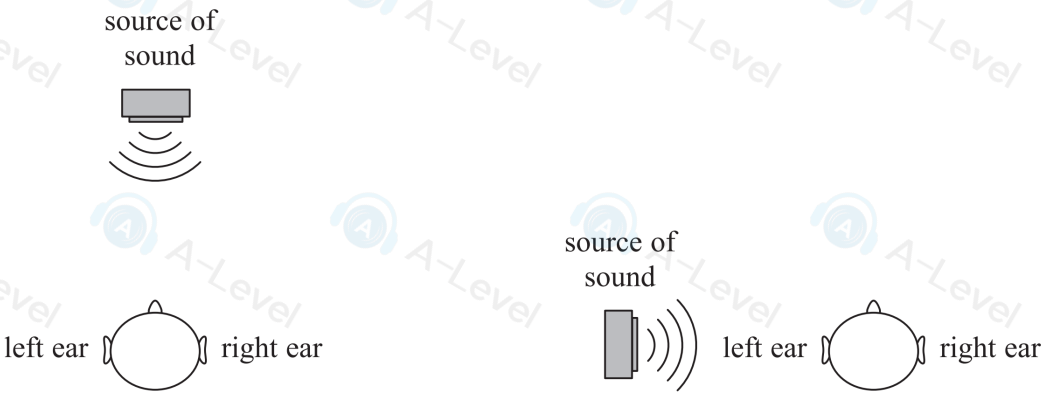
(a) Explain how sound travels through the air.

(3)

(b) What a listener hears depends on the position of the source of the sound.

The diagrams show a source of sound when it is placed

- in front of the listener
- to the left of the listener.



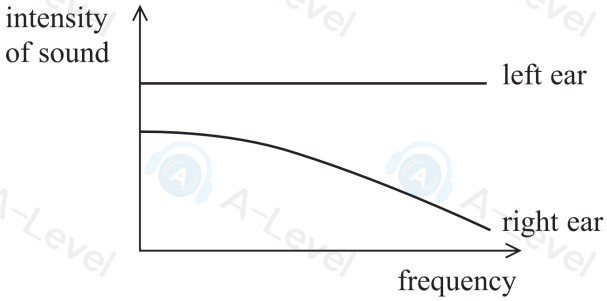
The sound waves from the source in front of the listener arrive at each ear at the same time.
The sound waves from the source to the left of the listener arrive at the left ear first.
The sound waves then reach the right ear by diffraction.

(i) Describe how the sound reaches the right ear by diffraction.

(2)

*(ii) The intensity of a sound heard by the ear is the power per unit area reaching the ear.

A particular source of sound is placed to the left of the listener. The graph shows how the intensity of the sound reaching each ear varies over a range of frequencies.



Explain the differences in the intensity of the sound reaching the left ear and the right ear.

(5)

(Total for Question 15 = 10 marks)