LONDON SCIENCE COLLEGE

Name:

Date:

WAVES
TEST 1

AS-Level

Mark

Grade

PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

- The marks for the questions are shown in brackets

1 **Figure 1** and **Figure 2** show a version of Quincke's tube, which is used to demonstrate interference of sound waves.

Figure 1

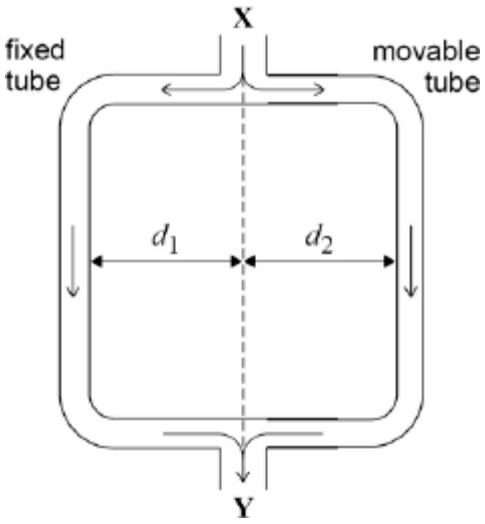
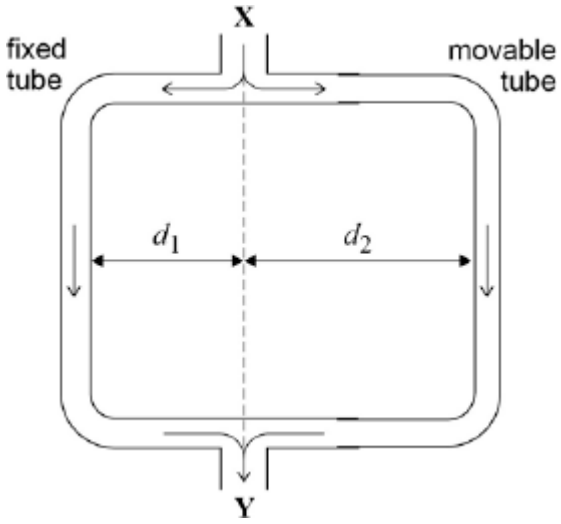


Figure 2



A loudspeaker at **X** produces sound waves of one frequency. The sound waves enter the tube and the sound energy is divided equally before travelling along the fixed and movable tubes. The two waves superpose and are detected by a microphone at **Y**.

(a) The movable tube is adjusted so that $d_1 = d_2$ and the waves travel the same distance from **X** to **Y**, as shown in **Figure 1**. As the movable tube is slowly pulled out as shown in **Figure 2**, the sound detected at **Y** gets quieter and then louder.

Explain the variation in the loudness of the sound at **Y** as the movable tube is slowly pulled out.

(4)

(b) The tube starts in the position shown in **Figure 1**.

Calculate the minimum distance moved by the movable tube for the sound detected at **Y** to be at its quietest.

frequency of sound from loud speaker = 800 Hz
speed of sound in air = 340 m s^{-1}

minimum distance moved = _____ m

(3)

(c) Quincke's tube can be used to determine the speed of sound.

State and explain the measurements you would make to obtain a value for the speed of sound using Quincke's tube and a sound source of known frequency.

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 11 marks)

2 The term **ultrasound** refers to vibrations in a material that occur at frequencies too high to be detected by a human ear. When ultrasound waves move through a solid, both longitudinal and transverse vibrations may be involved. For the longitudinal vibrations in a solid, the speed c of the ultrasound wave is given by

$$c = \sqrt{\frac{E}{\rho}}$$

where E is the Young modulus of the material and ρ is the density. Values for c and ρ are given in the table below.

Substance	c / m s^{-1}	ρ / kg m^{-3}
glass	5100	2500
sea water	1400	1000

Ultrasound waves, like electromagnetic radiation, can travel through the surface between two materials. When all the energy is transmitted from one material to the other, the materials are said to be **acoustically matched**. This happens when ρc is the same for both materials.

(a) Calculate the magnitude of the Young modulus for glass.

Young modulus = _____

(1)

(b) State your answer to (a) in terms of SI fundamental units.

(1)

(c) The passage states that 'when ultrasound waves move through a solid both longitudinal and transverse vibrations may be involved'.

State the difference between longitudinal and transverse waves.

_____

_____

_____

_____

(2)

(d) Show that when two materials are acoustically matched, the ratio of their Young moduli is equal to the ratio of their speeds of the ultrasound waves.

(2)

(e) The wave speed in a material X is twice that in material Y. X and Y are acoustically matched.

Determine the ratio of the densities of X and Y.

X = _____ Y = _____

(1)

(f) Ultrasound waves obey the same laws of reflection and refraction as electromagnetic waves.

Using data from **Table 1**, discuss the conditions for which total internal reflection can occur when ultrasound waves travel between glass and sea water.

(3)

(Total 10 marks)

3 Two points on a progressive wave are one-eighth of a wavelength apart. The distance between them is 0.5 m, and the frequency of the oscillation is 10 Hz. What is the minimum speed of the wave?

A 0.2 m s^{-1} ⬭

B 10 m s^{-1} ⬭

C 20 m s^{-1} ⬭

D 40 m s^{-1} ⬭

(Total 1 mark)

4 Which of the following waves **cannot** be polarised?

A radio ⬭

B ultrasonic ⬭

C microwave ⬭

D ultraviolet ⬭

(Total 1 mark)

5 Which of the following is correct for a stationary wave?

A Between two nodes the amplitude of the wave is constant. ⬭

B The two waves producing the stationary wave must always be 180° out of phase. ⬭

C The separation of the nodes for the second harmonic is double the separation of nodes for the first harmonic. ⬭

D Between two nodes all parts of the wave vibrate in phase. ⬭

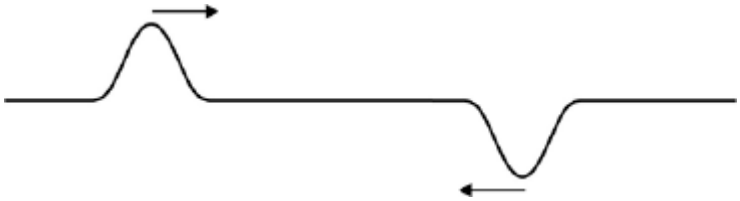
(Total 1 mark)

6 Sound waves cross a boundary between two media X and Y. The frequency of the waves in X is 400 Hz. The speed of the waves in X is 330 m s^{-1} and the speed of the waves in Y is 1320 m s^{-1}. What are the correct frequency and wavelength in Y?

	Frequency / Hz	**Wavelength / m**	
A	100	0.82	⬭
B	400	0.82	⬭
C	400	3.3	⬭
D	1600	3.3	⬭

(Total 1 mark)

7 The diagram shows two pulses on a string travelling towards each other.

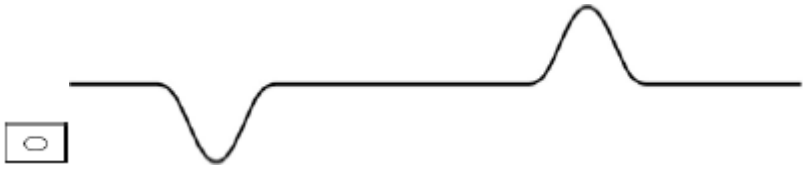


Which of the following diagrams shows the shape of the string when the pulses have passed through each other?

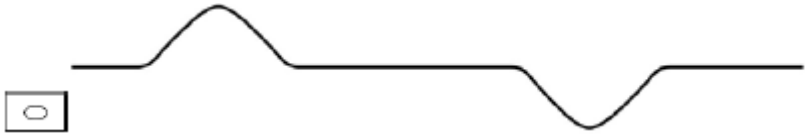
A

B

C



D



(Total 1 mark)

8 Which one of the following provides direct experimental evidence that light is a transverse wave motion rather than a longitudinal wave motion?

A Two light waves that are coherent can be made to interfere.

B Light can be diffracted.

C Light can be polarised.

D The intensity of light from a point source falls off inversely as the square of the distance from the source.

(Total 1 mark)

9 **Figure 1** is a diagram of a microwave oven.

Figure 1

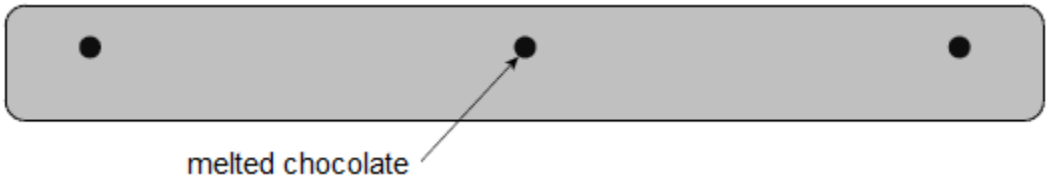
A student wants to use the stationary waves formed in the microwave oven to measure the frequency of the microwaves emitted by the transmitter.

(a) Suggest how stationary waves are formed in the microwave oven.

(2)

(b) The student removes the turntable and places a bar of chocolate on the floor of the oven. He then switches the oven on for about one minute. When the chocolate is removed the student observes that there are three small patches of melted chocolate with unmelted chocolate between them. **Figure 2** is a full-sized diagram of the chocolate bar.

Figure 2



Suggest why the chocolate only melts in the positions shown.

_____

_____

_____

_____

(2)

(c) Calculate, by making suitable measurements on **Figure 2**, the frequency of the microwaves used by the oven.

frequency = _____ Hz

(5)

(d) Explain why most microwave ovens contain a rotating turntable on which the food is placed during cooking.

_____

_____

_____

(1)

(Total 10 marks)

10 What is the phase difference between two points 0.16 m apart on a progressive sound wave of frequency 256 Hz?

speed of sound = 330 m s^{-1}

A $\frac{\pi}{8}$ ⬭

B $\frac{\pi}{6}$ ⬭

C $\frac{\pi}{4}$ ⬭

D $\frac{\pi}{3}$ ⬭

(Total 1 mark)

11 The frequency of the first harmonic of a standing wave on a wire is f. The length of the wire and tension in the wire are both doubled.

What is the frequency of the first harmonic as a result?

A $\frac{f}{\sqrt{2}}$ ⬭

B f ⬭

C $\sqrt{2}f$ ⬭

D $2f$ ⬭

(Total 1 mark)

12 (a) Explain what is meant by a progressive wave.

_____

_____

_____

(2)

(b) **Figure 1** shows the variation with time of the displacement of one point in a progressive wave.

Figure 1

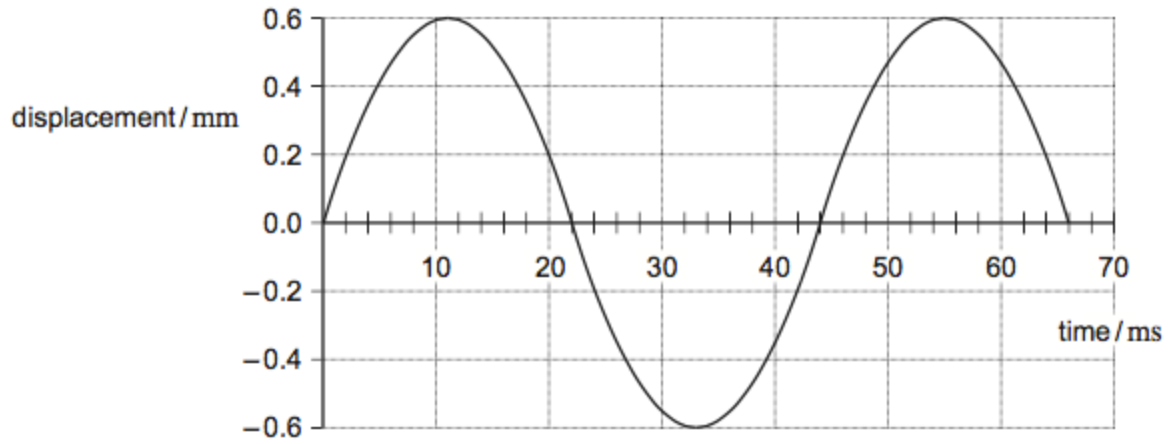
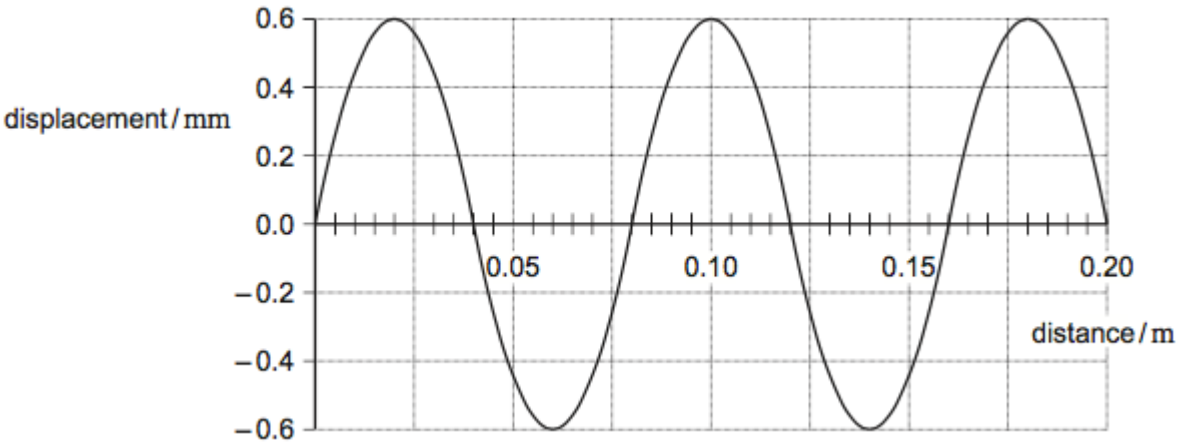


Figure 2 shows the variation of displacement of the same wave with distance.

Figure 2



Use **Figures 1 and 2** to determine

(i) the amplitude of the wave

amplitude = _____ mm

(1)

(ii) the wavelength of the wave

wavelength = _____ m

(1)

(iii) the frequency of the wave

frequency = _____ Hz

(1)

(iv) the speed of the wave

speed = _____ m s^{-1}

(1)

(c) Which of the following statements apply?
Place a tick (✓) in the right-hand column for each correct statement.

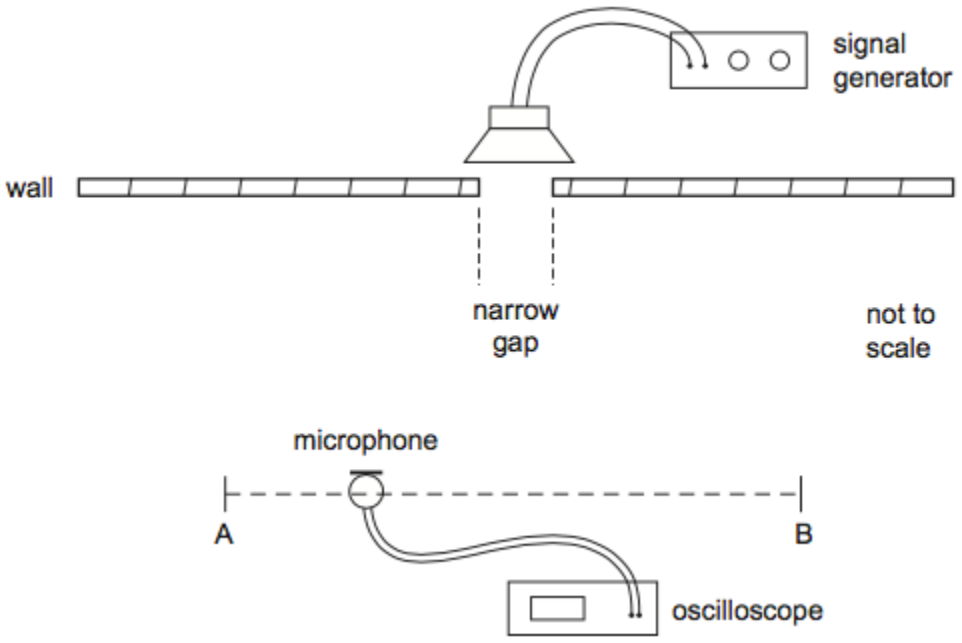
	✓ if correct
sound waves are transverse	
sound waves are longitudinal	
sound waves can interfere	
sound waves can be polarised	

(1)

(d) In an investigation, a single loudspeaker is positioned behind a wall with a narrow gap as shown in **Figure 3**.

A microphone attached to an oscilloscope enables changes in the amplitude of the sound to be determined for different positions of the microphone.

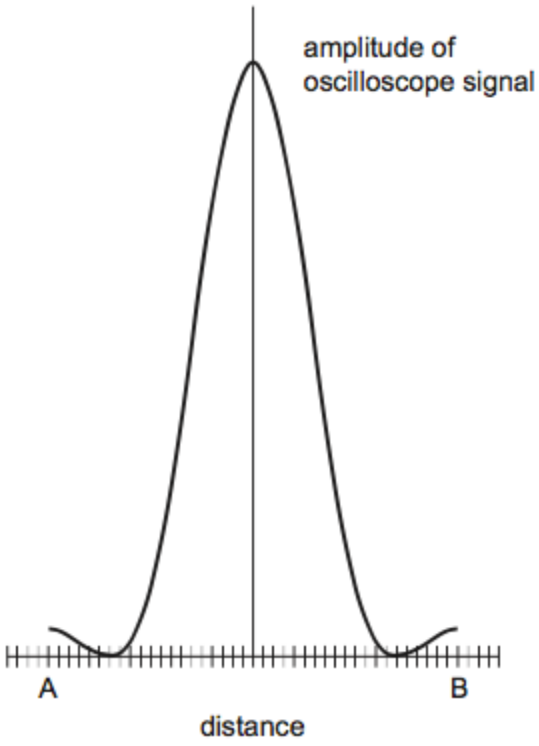
Figure 3



The amplitude of sound is recorded as the microphone position is moved along the line AB a large distance from the gap.

The result of the measurements is shown in **Figure 4**.

Figure 4



The signal generator is adjusted so that sound waves of the same amplitude but of a higher frequency are emitted by the loudspeaker. The investigation using the apparatus shown in **Figure 3** is then repeated.
Explain the effect this has on **Figure 4**.

(3)

(Total 10 marks)