1)

(a) Define the following terms as applied to wave motion

(i) *displacement* and *amplitude*

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.... **[2]**

(ii) *frequency* and *phase difference*.

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.... **[2]**

(b) Fig. 6.1 shows a transverse pulse on a *slinky*, an open wound spring, at time $t = 0$. The pulse is travelling at a speed of $0.50\,m\,s^{-1}$ from left to right. The front of the pulse is at point **X**, 0.25 m from the point **P**.

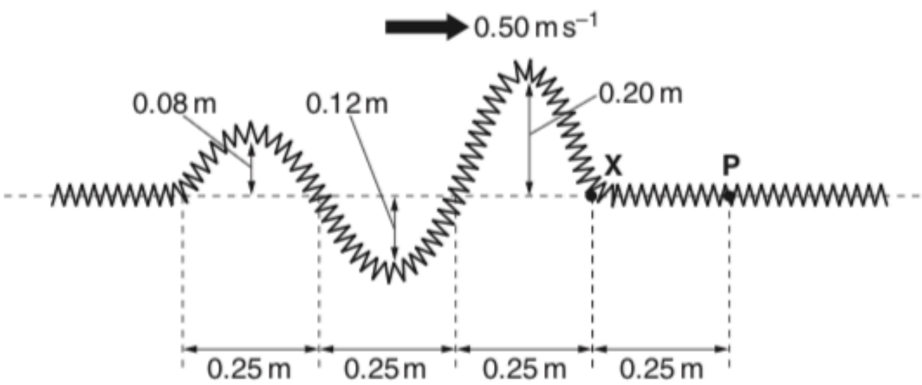

Fig. 6.1

On Fig. 6.2 draw a displacement y against time t graph of the motion of point **P** on the slinky from $t = 0$ to $t = 2.5$ s.

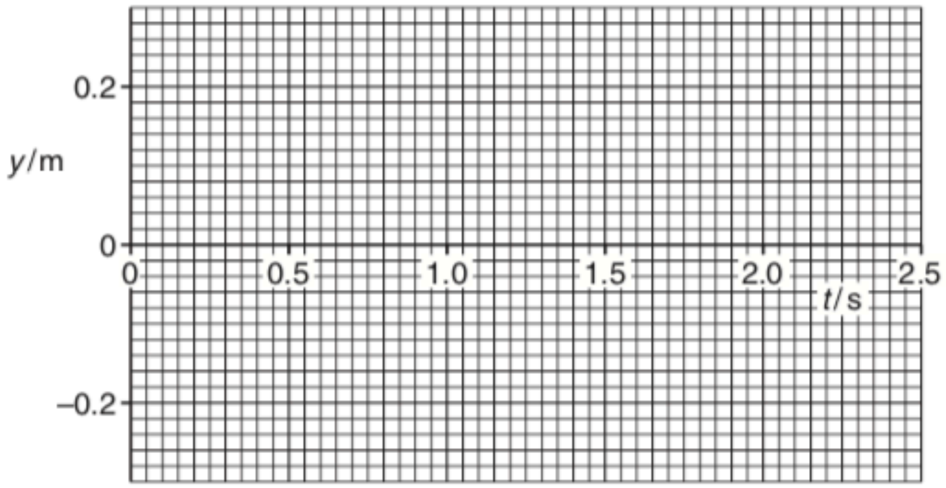

Fig. 6.2

[4]

[Total: 8]

2)

(a) Describe, in terms of vibrations, the difference between a longitudinal and a transverse wave. Give one example of each wave.

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.... **[4]**

(b) Fig. 6.1 shows a loudspeaker fixed near the end of a tube of length 0.6 m.

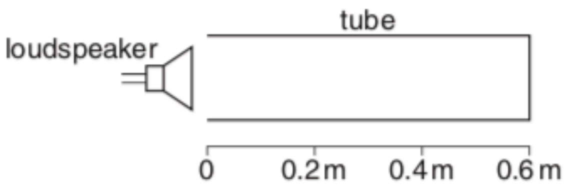

Fig. 6.1

The far end of the tube is closed. The frequency of the sound emitted from the loudspeaker is increased from zero. At a particular frequency a stationary wave is set up in the tube and the sound heard is much louder.

Explain how a stationary wave is formed in the tube.

In your answer, you should make clear how the stationary wave arises.

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.... **[3]**

(c) Figs. 6.2 and 6.3 show stationary wave patterns of amplitude against position along the tube at the fundamental frequency f_0 and the next possible harmonic at frequency $3f_0$.

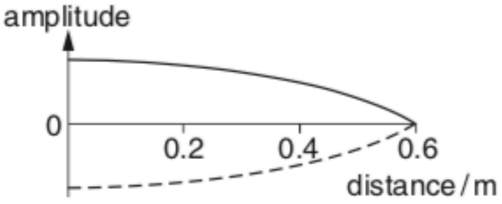

Fig. 6.2

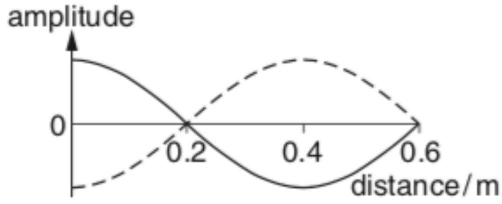

Fig. 6.3

Describe the motion of the air in the tube containing the stationary wave

(i) at points 0 m, 0.2 m and 0.6 m in Fig. 6.2

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....

.... **[2]**

(ii) at points 0 m, 0.2 m and 0.4 m in Fig. 6.3.

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.... **[2]**

(d) The end of the tube at 0.6 m from the loudspeaker is now opened.

(i) On Fig. 6.4 sketch the stationary wave pattern of amplitude against position along the tube at the new fundamental frequency. **[2]**

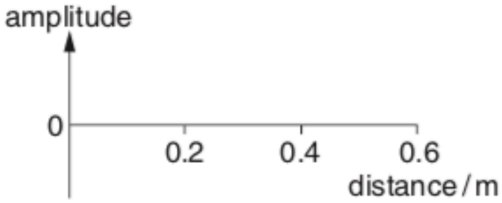

Fig. 6.4

(ii) State how the frequency of this stationary wave is related to the frequency f_0 of Fig. 6.2.

.... **[1]**

[Total: 14]

3)

(a) State **two** properties shared by all electromagnetic waves which distinguish them from all other waves.

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....

.... **[2]**

(b) The two columns below list four regions of the electromagnetic spectrum and four orders of magnitude of wavelength in m.

region	**wavelength / m**
microwaves	10^{-12}
ultra violet light	10^{-8}
gamma rays	10^{-6}
infra red light	10^{-4}

Draw a straight line from each **region** box to the corresponding **wavelength** box. **[2]**

(c) Fig. 8.1 shows a microwave receiver **R** placed between a microwave transmitter **T** and a flat metal sheet.

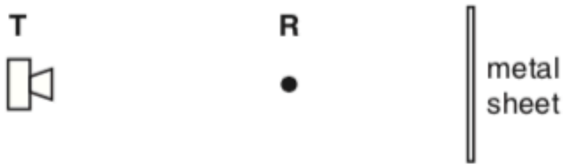

Fig. 8.1

(i) Explain why **R** receives two signals of different amplitude but of the same frequency.

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.... **[2]**

(ii) Explain why the strength of the detected signal varies between maximum and minimum values as **R** is moved towards or away from the metal sheet.

In your answer you should make clear how the maxima and minima occur.

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.... **[3]**

(iii) Determine the wavelength of the microwaves given that the distance between adjacent positions of maximum and minimum signal strength is 7.5 mm.

wavelength = ... mm **[1]**

(iv) The amplitude of the signal from the transmitter is *a*. The amplitude of the two signals detected at **R** are 0.8*a* and 0.6*a*. The changes in amplitude of the detected signals are negligible as **R** moves 7.5 mm. Show that the ratio

$$\frac{\text{maximum intensity of detected signal}}{\text{minimum intensity of detected signal}}$$

is about 50.

[3]

[Total: 13]

4)

Fig. 4.1 shows the variation with time t of the displacements x_S and x_T at a point **P** of two sound waves **S** and **T**.

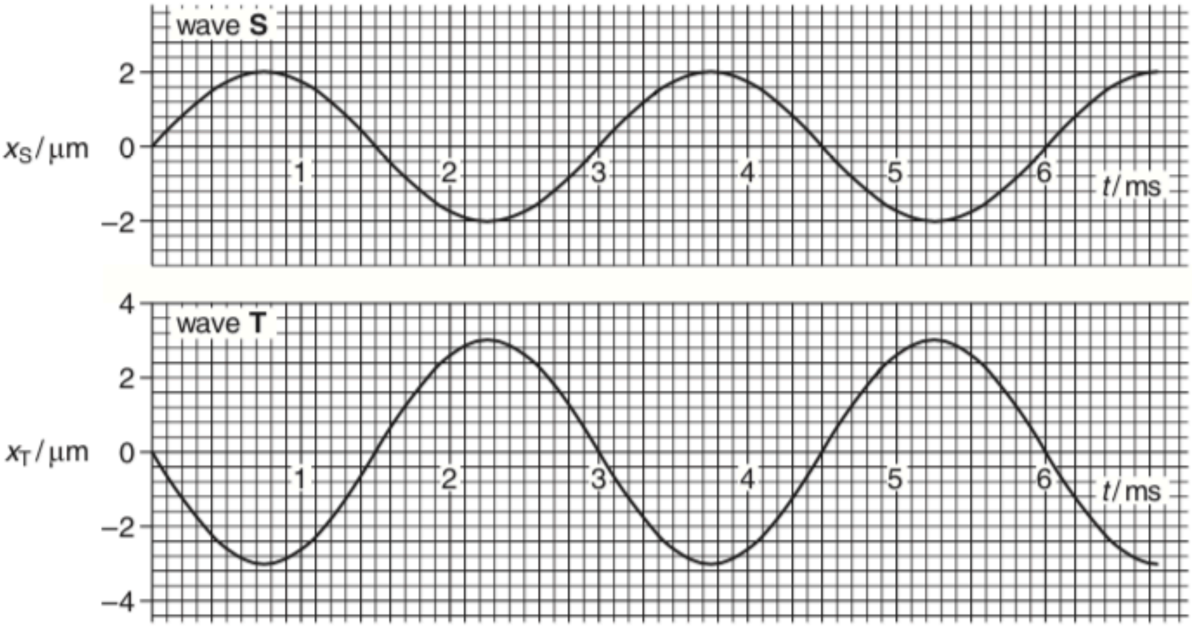

Fig. 4.1

(a) By reference to Fig. 4.1, state one similarity and one difference between these two waves.

similarity ....

difference .... **[2]**

(b) Explain whether or not the two waves are coherent.

....

....

.... **[2]**

(c) The speed of the sound waves is $340\,\text{m s}^{-1}$. Determine the frequency of wave **S** and hence its wavelength.

frequency = ... Hz

wavelength = ... m **[4]**

(d) At point **P** the two sound waves superpose (combine). By reference to Fig. 4.1 determine the resultant displacement x of the two waves at time

(i) $t_1 = 1.5\,\text{ms}$

x_1 = ... μm **[1]**

(ii) $t_2 = 2.25\,\text{ms}$.

x_2 = ... μm **[1]**

(e) The intensity of wave **S** alone at point **P** is I.

(i) Show that the intensity of wave **T** alone at point **P** is $2.25I$.

[2]

(ii) Calculate the intensity of the resultant wave at point **P** in terms of I.

intensity = ... I **[2]**

(f) The sound waves shown in Fig. 4.1 are emitted from the loudspeakers labelled **S** and **T** in Fig. 4.2 and detected by the microphone at point **P**.

Fig. 4.2

(i) Calculate the distance that loudspeaker **S** must be moved towards **P** to bring the two waves into phase at **P**. State your reasoning clearly.

distance = ... m **[2]**

(ii) Describe how the intensity of the sound wave detected at **P** varies as loudspeaker **S** is moved as in **(i)**.

....

....

.... **[2]**

[Total: 18]

5)

Fig. 4.1 shows the variation with time t of the displacement y of the air at a point **P** in front of a loudspeaker emitting a sound wave of a single frequency.

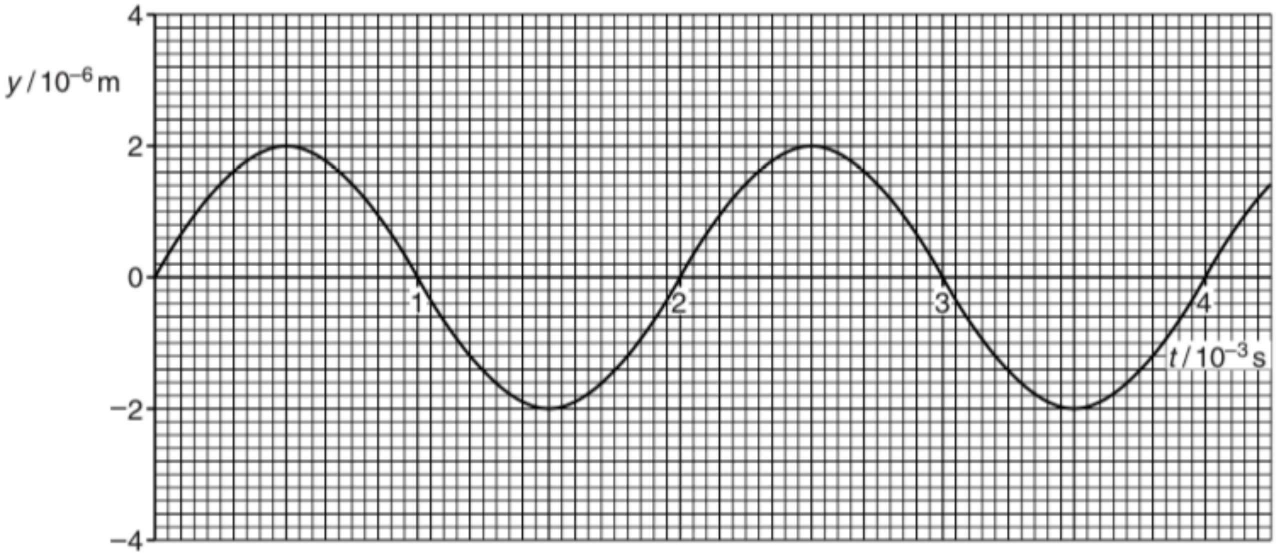

Fig. 4.1

(a) Calculate

(i) the frequency f of oscillation of the air at **P**

f = ... Hz **[2]**

(ii) the wavelength λ of the wave which is travelling at 340 m s^{-1}.

λ = ... m **[2]**

(b) Draw on Fig. 4.1 the variation with time of the displacement of the air at a point **Q** a distance of one quarter of a wavelength $\lambda/4$ beyond **P**. Label this curve **Q.** **[2]**

(c) Explain the meaning of the term *phase difference*. Illustrate your answer by stating the phase difference between the displacements of the air at the points **P** and **Q**.

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.... **[3]**

(d) The amplitude of vibration of the loudspeaker is increased to produce a wave at the original frequency, but of twice the **intensity**. Sketch on Fig. 4.1 the new displacement against time graph, for $t = 0$ to $t = 2 \times 10^{-3}$ s, at point **P**. Label this curve **P**. Explain your reasoning.

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.... **[3]**

(e) An open tube is placed in front of the loudspeaker such that its far end is at point **Q**. See Fig. 4.2.

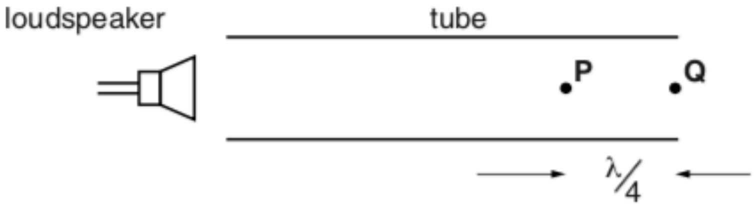

Fig. 4.2

(i) Explain how and under what conditions a stationary sound wave is formed in the tube.

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.... **[3]**

(ii) Assume that the conditions are met for a stationary wave to be set up in the tube. The distance between the points **P** and **Q** is $\lambda/4$.

Describe the motion of the air molecules

1 at point **Q**

....

....

....

2 at point **P**.

....

....

.... **[3]**

[Total: 18]

6)

An estimation of the speed of electromagnetic waves can be made using the hot spots inside a microwave oven. Microwaves are emitted in all directions inside the metal walls of the oven at a frequency of 2.5×10^9 Hz causing stationary waves to be set up. Fig. 7.1 shows a typical pattern of the centres of the hot spots marked **X** in the central area of the floor of the oven.

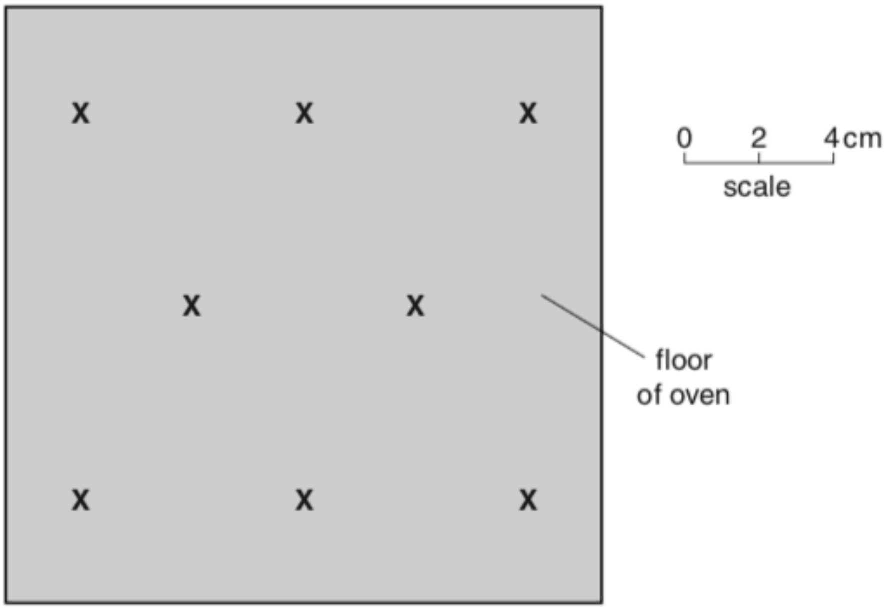

Fig. 7.1

These positions can be located to within a few millimetres by melting small areas in a bar of chocolate placed on the floor of the oven for a few seconds.

(a) Explain how a stationary microwave pattern is set up in the oven.

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.... **[3]**

(b) Explain whether the points marked **X** on Fig. 7.1 are at nodes or antinodes in the wave pattern.

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....

....

.... **[2]**

(c) Fig. 7.1 is drawn to **half scale**. By using measurements taken from the diagram make an estimate of the speed *c* of the microwaves. Make your reasoning clear.

c = ... $\mathrm{m\,s^{-1}}$ **[4]**

[Total: 9]

7)

Fig. 5.1 shows a long plastic tube immersed in a deep tank of water. A loudspeaker emitting a sound of constant frequency 512 Hz is fixed to the end of the tube. The tube is raised out of the water until a loud sound is first heard, position **P**. The tube is raised again until a loud sound is heard for a second time, position **Q**. The distance that the tube is raised between the two positions of loud sound is shown in the diagram.

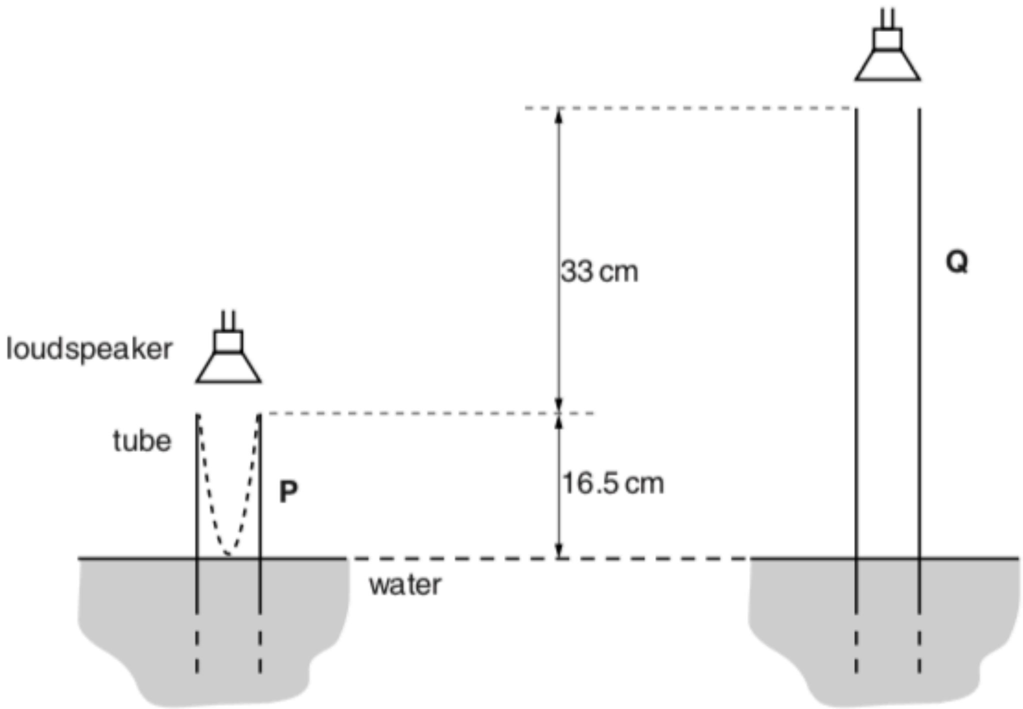

Fig. 5.1

The tube is narrow enough for end corrections to be ignored.

(i) The dotted line in the tube when at position **P** illustrates the stationary wave produced in the tube.

1 Sketch on Fig. 5.1 the stationary wave formed in the tube when at position **Q**. **[1]**

2 On your sketch, label the positions of all nodes with the letter **N**, and all antinodes with the letter **A**. **[2]**

(ii) Calculate the speed v of sound in the tube.

v = ... $m\,s^{-1}$ **[3]**

The length of the tube is 66 cm. The tube is removed completely from the water with the loudspeaker continuing to emit the same frequency of 512 Hz. A loud sound is again heard.

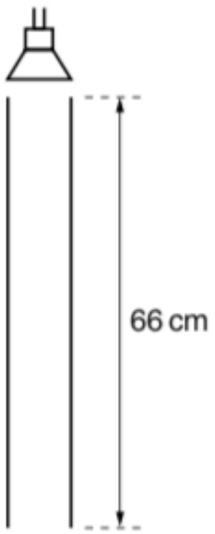

Fig. 5.2

Fig. 5.3

(i) Sketch on Fig. 5.2 the stationary wave now produced in the tube. **[1]**

(ii) **1** State the fundamental frequency f_0 of the stationary wave in the open tube.

f_0 = ... Hz **[1]**

2 On Fig. 5.3 sketch the fundamental mode of vibration in the open tube. **[1]**

(iii) Explain why the stationary wave in Fig. 5.2 is the second harmonic for an open pipe.

....

....

.... **[2]**