8 **(a)** Explain how stationary waves are formed.

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……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(b) A microphone that is connected to a cathode-ray oscilloscope (c.r.o.) is used by a student to detect the sound from a loudspeaker. Fig. 8.1 shows the trace on the screen of the c.r.o.

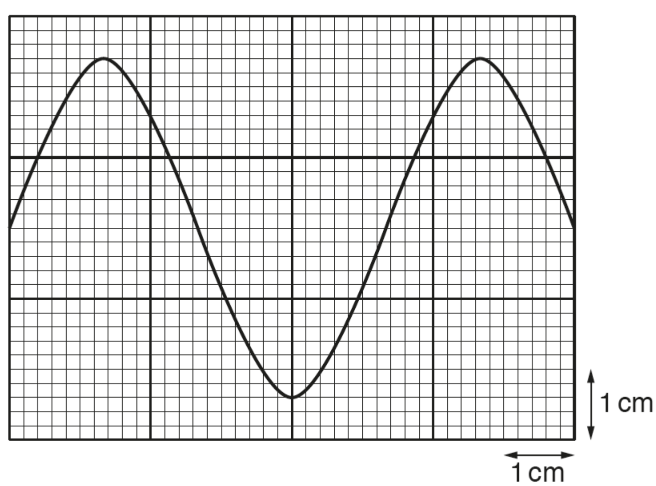

Fig. 8.1

In air, the sound wave has a speed of 330 m s^{-1} and a wavelength of 0.18 m.

(i) Calculate the frequency of the sound wave.

frequency = ... Hz [1]

(ii) Determine the time-base setting, in s cm^{-1}, of the c.r.o.

time-base setting = ... s cm^{-1} [1]

(iii) The intensity of the sound from the loudspeaker is now halved. The wavelength of the sound is unchanged. Assume that the amplitude of the trace is proportional to the amplitude of the sound wave.

On Fig. 8.1, sketch the new trace shown on the screen of the c.r.o. [2]

(c) Next, the student fills a long tube, fitted with a tap, with liquid. The loudspeaker in **(b)** is held above the top of the vertical tube as the liquid is allowed to run out of the tube, as shown in Fig. 8.2.

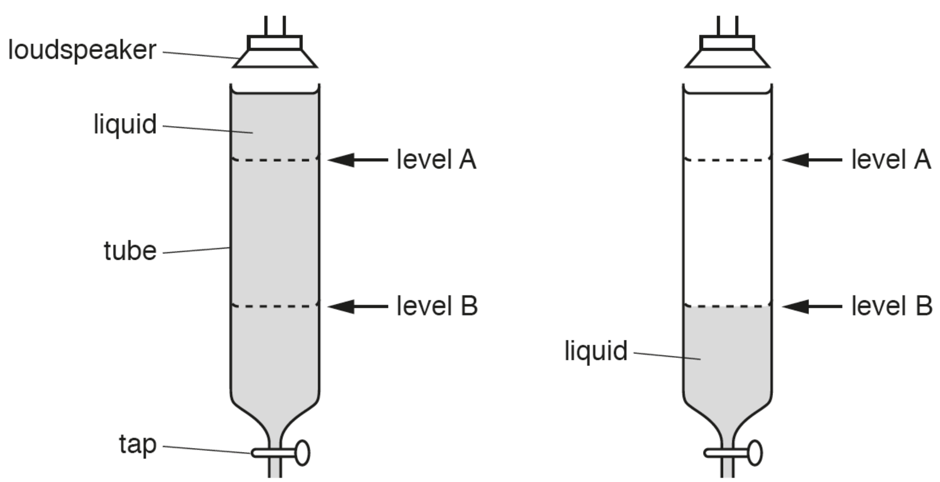

Fig. 8.2 **Fig. 8.3**

A loud sound is first heard when the liquid level reaches level A and then heard again when the liquid level reaches B, as shown in Fig. 8.3.

(i) Calculate the vertical distance between level A and level B.

vertical distance = ... m [1]

(ii) The mass of the liquid leaving the tube per unit time is 6.7 g s^{-1}. The tube has an internal cross-sectional area of 13 cm^2. The density of the liquid is 0.79 g cm^{-3}.

Calculate the time taken for the liquid to move from level A to level B.

time = ... s [2]

(d) The student sets up two loudspeakers S_1 and S_2 that are situated 100 cm apart in air, as shown in Fig. 8.4. A microphone M is situated a distance 140 cm from S_1 along a line that is normal to S_1S_2.

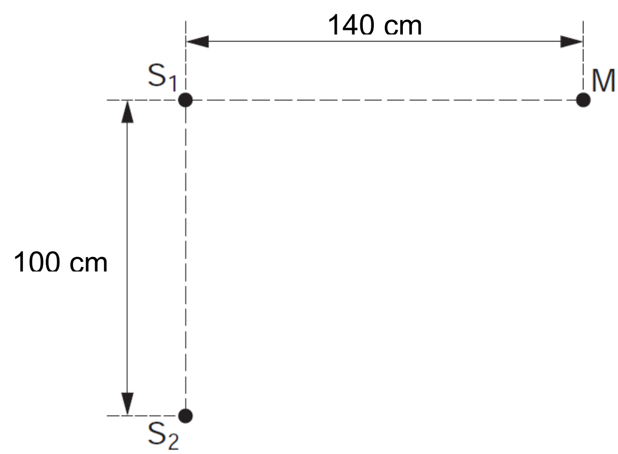

Fig. 8.4

The two loudspeakers always vibrate in phase and the frequency of vibration can be varied.

As the frequency of S_1 and S_2 is gradually increased, the microphone M detects maxima and minima of intensity of sound.

(i) State one condition that must be satisfied for the intensity of sound at M to be maximum.

……..…..

....[1]

(ii) The speed of sound in air is 330 m s^{-1}.

The frequency of the sound from S_1 and S_2 is increased. Determine the number of maxima that will be detected at M as the frequency is increased from 1.0 kHz to 4.0 kHz.

number = ………………………………… [3]

(e) The student moves on to explore with a laser of wavelength 633 nm. The laser is placed behind a glass microscope slide that has been painted black. A single vertical slit of width 0.0800 mm has been produced by scratching through the paint with a razor blade.

Light from the laser passes through the slit and hits a wall at a distance of 5.12 m from the slit. A light sensor connected to a data logger is moved across the wall and the variation with distance moved by the sensor of the intensity of light is shown in Fig. 8.5.

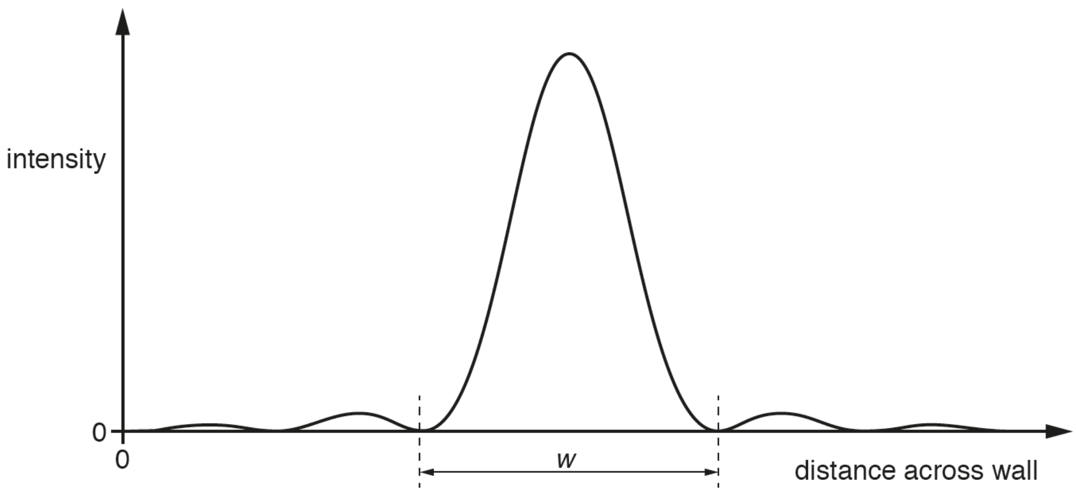

Fig. 8.5

The width *w* of the central patch is equal to the distance between the two minimum points on either side of the central patch where the intensity of the light is equal to zero.

(i) Determine *w*.

w = ... m [2]

(ii) A second vertical slit of width 0.0800 mm is scratched across the slide. The second slit is parallel to the first and its centre is a horizontal distance of 0.240 mm away from the centre of the first slit.

The slide now acts as a double slit. At the centre of the double-slit interference pattern on the wall, there are bright and dark fringes which are uniformly spaced.

1. Some parts of the screen that were brightly lit when only the first slit was present are now dark, even though the light is still passing through the first slit in the same way.

Explain what causes this to happen.

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………………………………………………………………………………………………
[1]

2. Determine the separation *x* of the bright fringes.

x = ………………………………… m [2]

3. Most of the bright fringes are separated from adjacent bright fringes by a distance *x*. In a few places, away from the centre, however, there are separations of 2*x* and there is no light in the middle of the gap where a bright fringe might be expected.

Using the results from **(e)(i)** and **(e)(ii)2**, explain why there is no light at such places.

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[2]