14 (a) State the difference between a stationary wave and a progressive wave in terms of

(i) the energy transfer along the wave,

....

....[1]

(ii) the phase of two adjacent vibrating particles.

....

....[1]

(b) A tube is open at both ends. A loudspeaker, emitting sound of a single frequency, is placed near one end of the tube, as shown in Fig. 3.1.

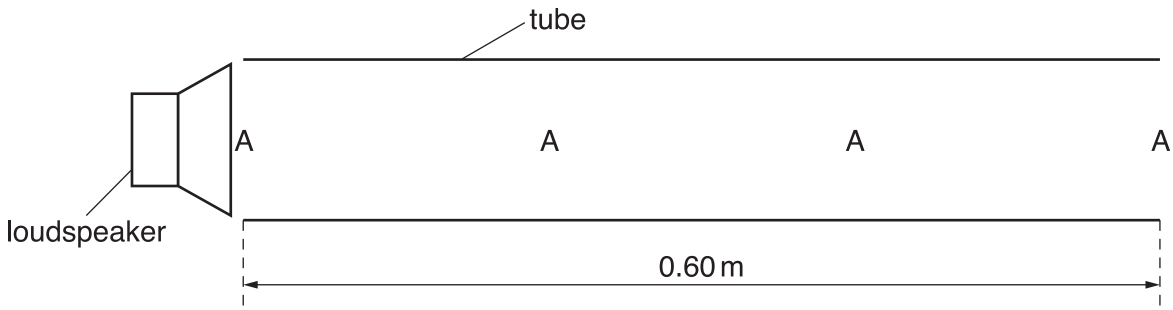

Fig. 3.1

The speed of the sound in the tube is $340\,m\,s^{-1}$. The length of the tube is 0.60 m.
A stationary wave is formed with an antinode A at each end of the tube and two antinodes inside the tube.

(i) State what is meant by an *antinode* of the stationary wave.

....

....[1]

(ii) State the distance between a node and an adjacent antinode.

distance = ... m [1]

(iii) Determine, for the sound in the tube,

1. the wavelength,

wavelength = ... m [1]

2. the frequency.

frequency = ... Hz [2]

(iv) Determine the minimum frequency of the sound from the loudspeaker that produces a stationary wave in the tube.

minimum frequency = ... Hz [2]

[Total: 9]

15 **(a)** State the conditions required for the formation of a stationary wave.

....

....

....

....[2]

(b) A horizontal string is stretched between two fixed points X and Y. The string is made to vibrate vertically so that a stationary wave is formed. At one instant, each particle of the string is at its maximum displacement, as shown in Fig. 4.1.

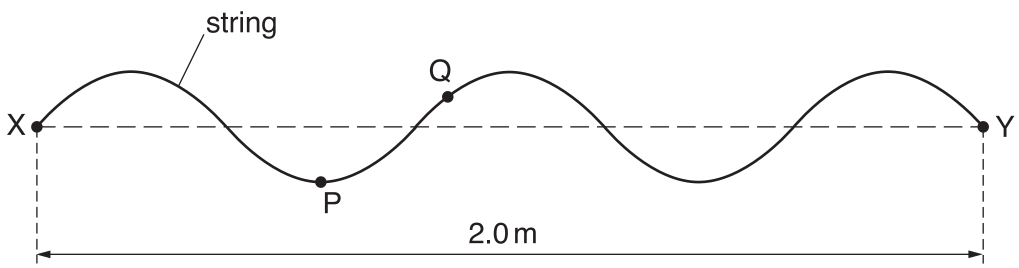

Fig. 4.1

P and Q are two particles of the string. The string vibrates with a frequency of 40 Hz. Distance XY is 2.0 m.

(i) State the number of antinodes in the stationary wave.

number = ...[1]

(ii) Determine the minimum time taken for the particle P to travel from its lowest point to its highest point.

time taken = ... s [2]

(iii) State the phase difference, with its unit, between the vibrations of particle P and of particle Q.

phase difference = ...[1]

(iv) Determine the speed of a progressive wave along the string.

speed = ... $m\,s^{-1}$ [2]

[Total: 8]

16 **(a)** State the conditions required for the formation of a stationary wave.

....

....

....

....[2]

(b) The sound from a loudspeaker is detected by a microphone that is connected to a cathode-ray oscilloscope (c.r.o.). Fig. 4.1 shows the trace on the screen of the c.r.o.

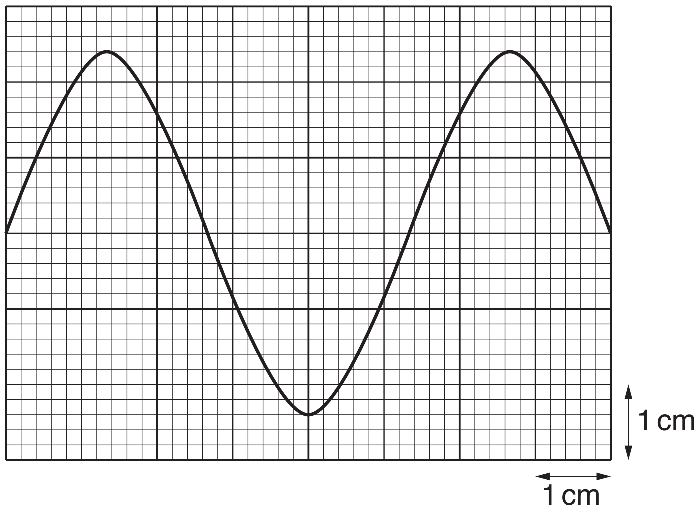

Fig. 4.1

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

(i) Calculate the frequency of the sound wave.

frequency = ... Hz [2]

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

time-base setting = ... $\mathrm{s\,cm^{-1}}$ [2]

(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. 4.1, sketch the new trace shown on the screen of the c.r.o. [2]

(c) The loudspeaker in **(b)** is held above a vertical tube of liquid, as shown in Fig. 4.2.

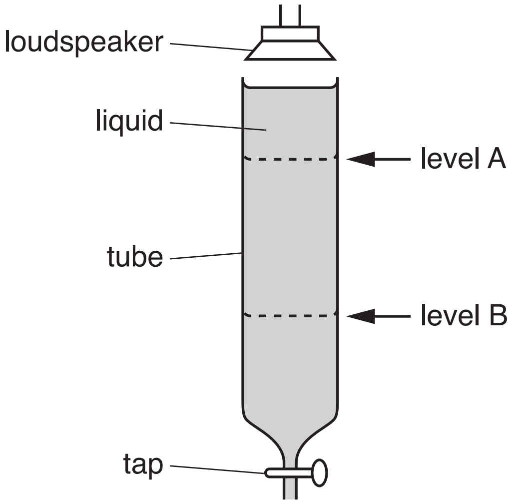

Fig. 4.2

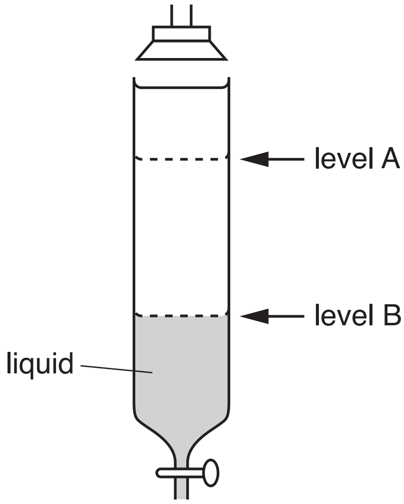

Fig. 4.3

A tap at the bottom of the tube is opened so that liquid drains out at a constant rate. The wavelength of the sound from the loudspeaker is 0.18 m. The sound that is heard first becomes much louder when the liquid surface reaches level A. The next time that the sound becomes much louder is when the liquid surface reaches level B, as shown in Fig. 4.3.

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

distance = ... m [1]

(ii) **On Fig. 4.3**, label with the letter N the positions of the nodes of the stationary wave that is formed in the air column when the liquid surface is at level B. [1]

(iii) The mass of 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]

[Total: 12]

17 **(a)** **(i)** Define the *wavelength* of a progressive wave.

....

....[1]

(ii) State what is meant by an *antinode* of a stationary wave.

....

....[1]

(b) A loudspeaker producing sound of constant frequency is placed near the open end of a pipe, as shown in Fig. 4.1.

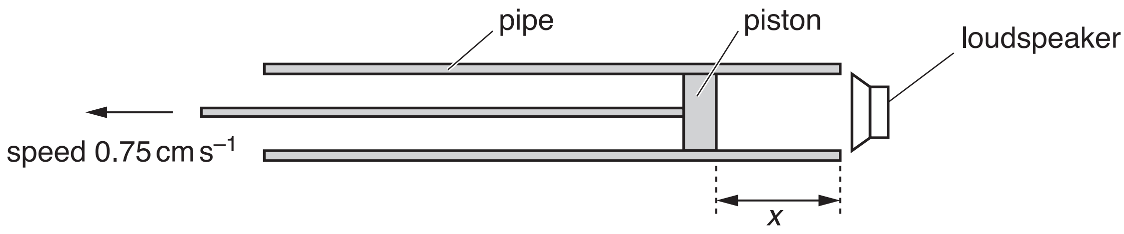

Fig. 4.1

A movable piston is at distance x from the open end of the pipe. Distance x is increased from x 0 by moving the piston to the left with a constant speed of $0.75\,\mathrm{cm\,s^{-1}}$.

The speed of the sound in the pipe is $340\,\mathrm{m\,s^{-1}}$.

(i) A much louder sound is first heard when $x = 4.5\,\mathrm{cm}$. Assume that there is an antinode of a stationary wave at the open end of the pipe.

Determine the frequency of the sound in the pipe.

frequency = ... Hz [3]

(ii) After a time interval, a second much louder sound is heard. Calculate the time interval between the first louder sound and the second louder sound being heard.

time interval = ...s [2]

[Total: 7]

18 (a) On Fig. 4.1, complete the two graphs to illustrate what is meant by the amplitude A, the wavelength λ and the period T of a progressive wave.

Ensure that you label the axes of each graph.

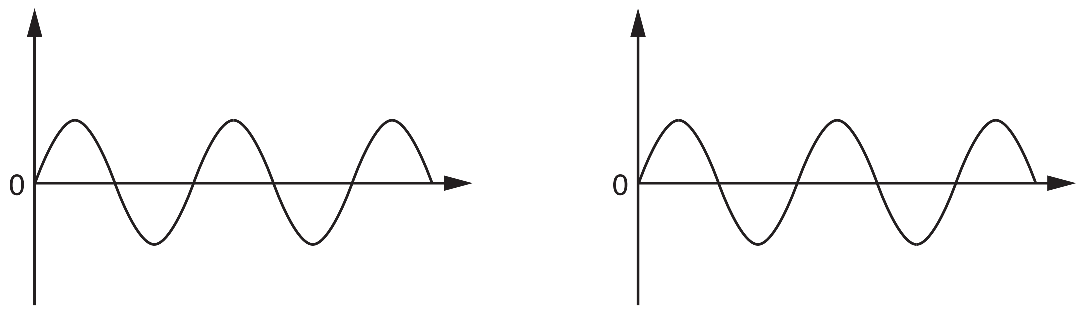

Fig. 4.1

[3]

(b) A horizontal string is stretched between two fixed points X and Y. A vibrator is used to oscillate the string and produce a stationary wave. Fig. 4.2 shows the string at one instant in time.

Fig. 4.2

The speed of a progressive wave along the string is $30\,\mathrm{m\,s^{-1}}$. The stationary wave has a period of 40 ms.

(i) Explain how the stationary wave is formed on the string.

....

....

....

....[2]

(ii) A particle on the string oscillates with an amplitude of 13 mm. At time t, the particle has zero displacement.

Calculate

1. the displacement of the particle at time (t + 100 ms),

displacement = ... mm

2. the total distance moved by the particle from time t to time (t + 100 ms).

distance = ... mm [3]

(iii) Determine

1. the frequency of the wave,

frequency = ... Hz [1]

2. the horizontal distance from X to Y.

distance = ... m [3]

[Total: 12]

19 A vertical tube of length 0.60 m is open at both ends, as shown in Fig. 5.1.

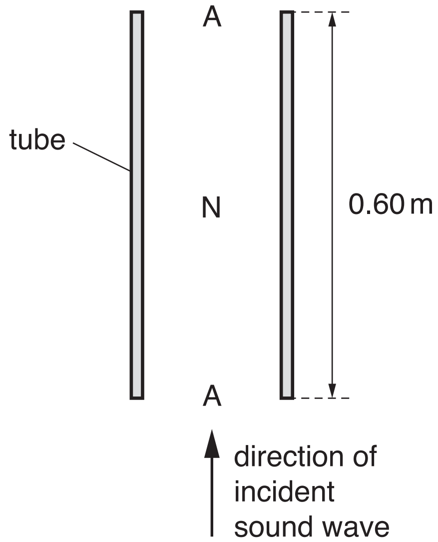

Fig. 5.1

An incident sinusoidal sound wave of a single frequency travels up the tube. A stationary wave is then formed in the air column in the tube with antinodes A at both ends and a node N at the midpoint.

(a) Explain how the stationary wave is formed from the incident sound wave.

....

....

....

....[2]

(b) On Fig. 5.2, sketch a graph to show the variation of the amplitude of the stationary wave with height h above the bottom of the tube.

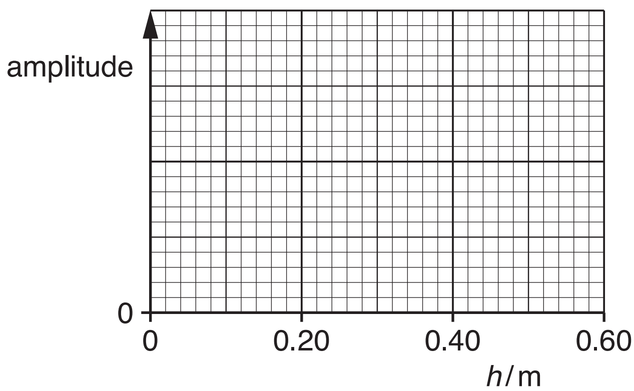

Fig. 5.2

[2]

(c) For the stationary wave, state:

(i) the direction of the oscillations of an air particle at a height of 0.15 m above the bottom of the tube

....[1]

(ii) the phase difference between the oscillations of a particle at a height of 0.10 m and a particle at a height of 0.20 m above the bottom of the tube.

phase difference = ... ° [1]

(d) The speed of the sound wave is $340\,m\,s^{-1}$.

Calculate the frequency of the sound wave.

frequency = ... Hz [2]

(e) The frequency of the sound wave is gradually increased.

Determine the frequency of the wave when a stationary wave is next formed.

frequency = ... Hz [1]

[Total: 9]