5 The variation with time t of the displacement y of a wave X, as it passes a point P, is shown in Fig. 5.1.

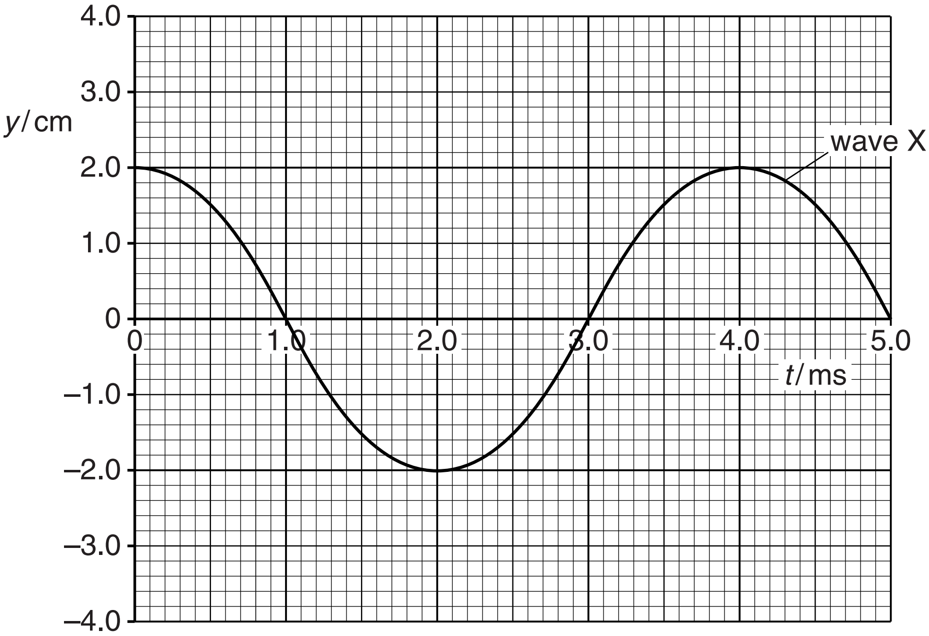


Fig. 5.1

The intensity of wave X is I.

(a) Use Fig. 5.1 to determine the frequency of wave X.

frequency = ... Hz [2]

(b) A second wave Z with the same frequency as wave X also passes point P.
Wave Z has intensity $2I$. The phase difference between the two waves is 90°.

On Fig. 5.1, sketch the variation with time t of the displacement y of wave Z.

Show your working.

[3]

(c) A double-slit interference experiment is used to determine the wavelength of light emitted from a laser, as shown in Fig. 5.2.

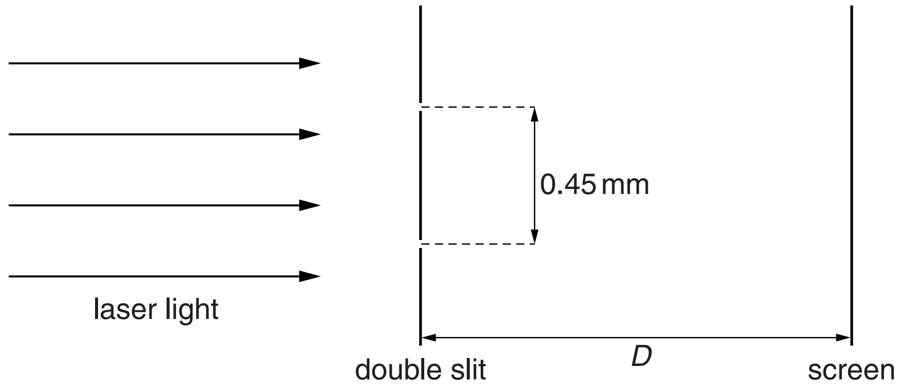


Fig. 5.2 (not to scale)

The separation of the slits is 0.45 mm. The fringes are viewed on a screen at a distance D from the double slit.

The fringe width x is measured for different distances D. The variation with D of x is shown in Fig. 5.3.

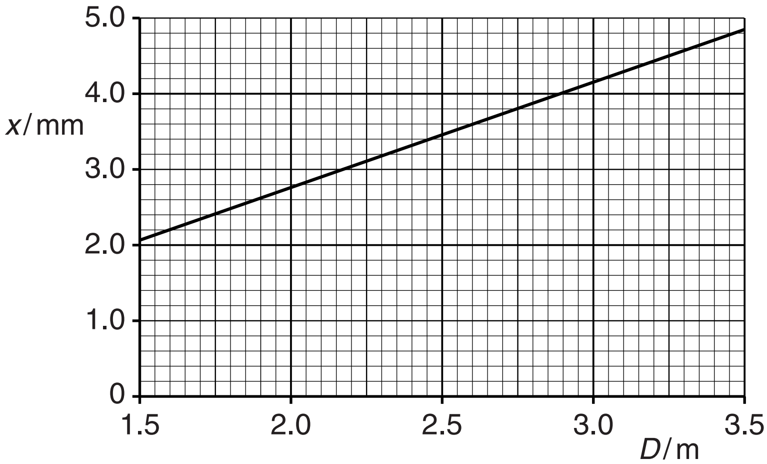


Fig. 5.3

(i) Use the gradient of the line in Fig. 5.3 to determine the wavelength, in nm, of the laser light.

wavelength = ... nm [4]

(ii) The separation of the slits is increased. State and explain the effects, if any, on the graph of Fig. 5.3.

....

....

....[2]

[Total: 11]

4 **(a)** **(i)** By reference to the direction of propagation of energy, state what is meant by a *transverse* wave.

....

.... [1]

(ii) State the principle of superposition.

....

....

.... [2]

(b) Circular water waves may be produced by vibrating dippers at points P and Q, as illustrated in Fig. 4.1.

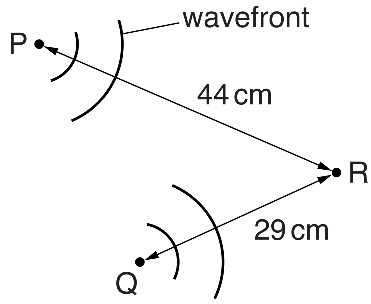


Fig. 4.1 (not to scale)

The waves from P alone have the same amplitude at point R as the waves from Q alone. Distance PR is 44 cm and distance QR is 29 cm.

The dippers vibrate in phase with a period of 1.5 s to produce waves of speed 4.0 cm s^{-1}.

(i) Determine the wavelength of the waves.

wavelength = ... cm [2]

(ii) By reference to the distances PR and QR, explain why the water particles are at rest at point R.

....

....

....

....

.... [3]

(c) A wave is produced on the surface of a different liquid. At one particular time, the variation of the vertical displacement *y* with distance *x* along the surface of the liquid is shown in Fig. 4.2.

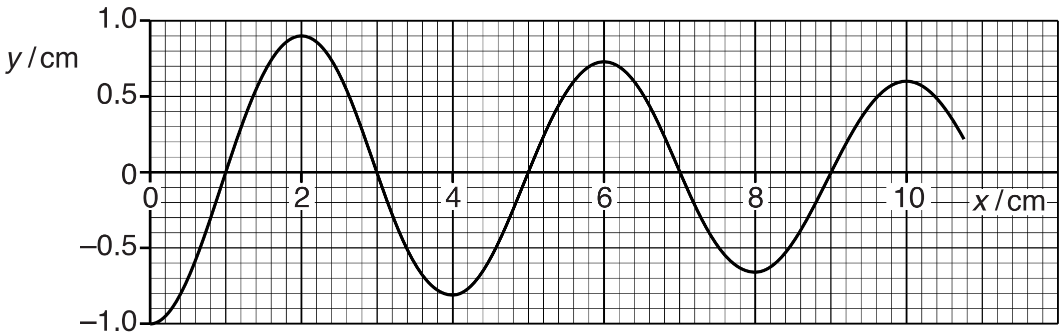


Fig. 4.2

(i) The wave has intensity I_1 at distance $x = 2.0\,\text{cm}$ and intensity I_2 at $x = 10.0$ cm.

Determine the ratio

$$\frac{\text{intensity } I_2}{\text{intensity } I_1}.$$

ratio = ... [2]

(ii) State the phase difference, with its unit, between the oscillations of the liquid particles at distances $x = 3.0\,\text{cm}$ and $x = 4.0\,\text{cm}$.

phase difference = ... [1]

[Total: 11]

Answer **all** the questions in the spaces provided.

1 **(a)** The intensity of a progressive wave is defined as the average power transmitted through a surface per unit area.

Show that the SI base units of intensity are $\mathrm{kg\,s^{-3}}$.

[2]

(b) **(i)** The intensity I of a sound wave is related to the amplitude x_0 of the wave by

$$I = K\rho c f^2 x_0^{\,2}$$

where ρ is the density of the medium through which the sound is passing,
c is the speed of the sound wave,
f is the frequency of the sound wave
and K is a constant.

Show that K has no units.

[2]

(ii) Calculate the intensity, in $\mathrm{pW\,m^{-2}}$, of a sound wave where

$K = 20$,
$\rho = 1.2$ in SI base units,
$c = 330$ in SI base units,
$f = 260$ in SI base units
and $x_0 = 0.24\,\mathrm{nm}$.

intensity = ... $\mathrm{pW\,m^{-2}}$ [3]

2 A signal generator is connected to two loudspeakers L_1 and L_2, as shown in Fig. 2.1.

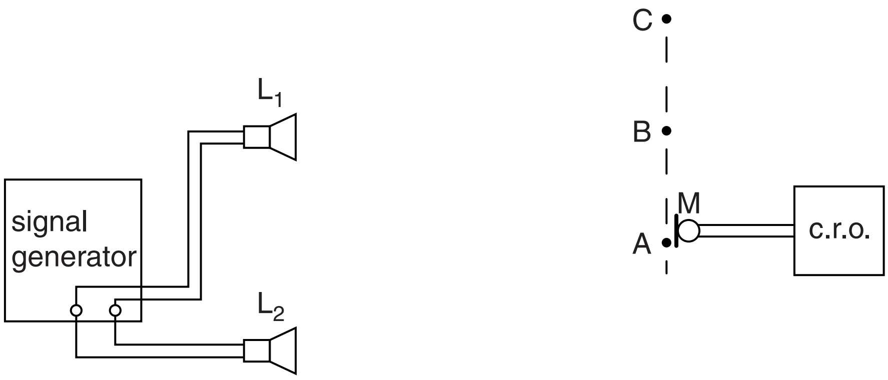
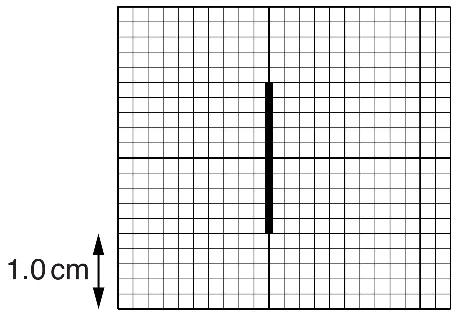


Fig. 2.1

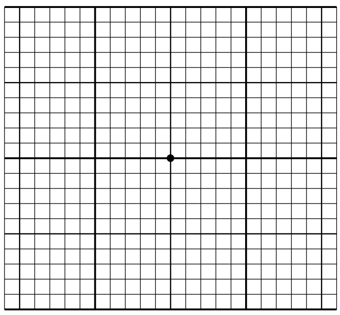
A microphone M, connected to the Y-plates of a cathode-ray oscilloscope (c.r.o.), detects the intensity of sound along the line ABC.
The distances L_1A and L_2A are equal.
The time-base of the c.r.o. is switched off.

The traces on the c.r.o. when M is at A, then at B and then at C are shown on Fig. 2.2, Fig. 2.3 and Fig. 2.4 respectively.



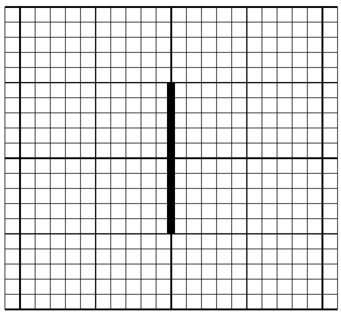
M at A

Fig. 2.2



M at B

Fig. 2.3



M at C

Fig. 2.4

For these traces, 1.0 cm represents 5.0 mV on the vertical scale.

(a) **(i)** Explain why coherent waves are produced by the loudspeakers.

....

....

....[1]

(ii) Use the principle of superposition to explain the traces shown with M at

1. A,

....

....

....[1]

2. B,

....

....

....[1]

3. C.

....

....

....[1]

(b) The sound emitted from L_1 and L_2 has frequency 500 Hz. The time-base on the c.r.o. is switched on.

The microphone M is placed at A.

On Fig. 2.5, draw the trace seen on the c.r.o.

On the vertical scale, 1.0 cm represents 5.0 mV. On the horizontal scale, 1.0 cm represents 0.10 ms.

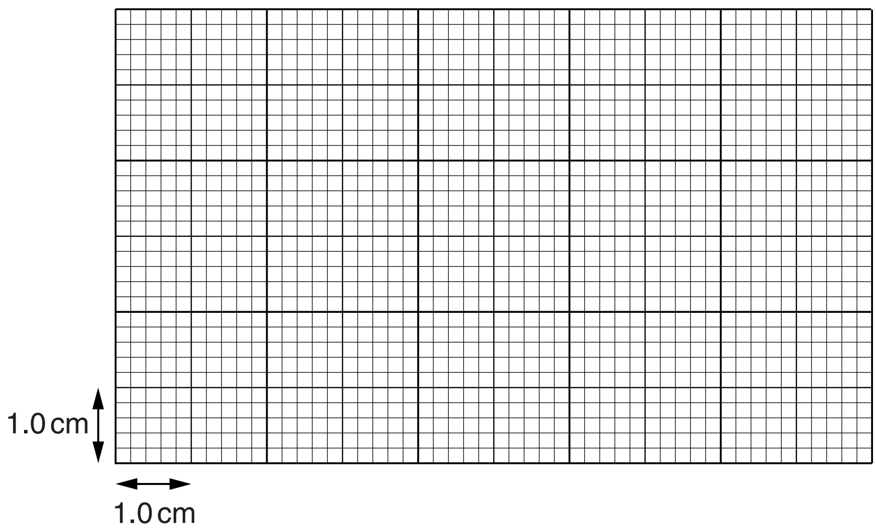


Fig. 2.5

[3]

6 An arrangement for producing stationary waves in air in a tube that is closed at one end is shown in Fig. 6.1.

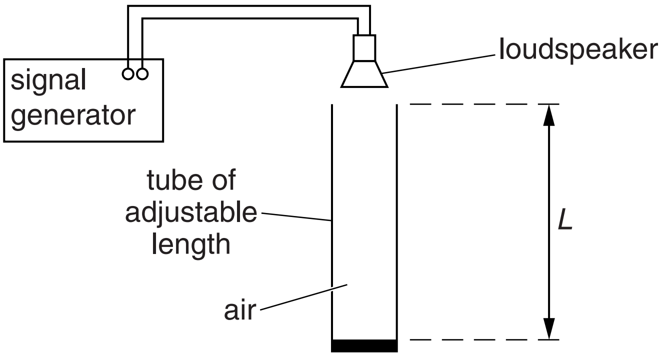


Fig. 6.1

A loudspeaker produces sound waves of wavelength 0.680 m in the tube.
For some values of the length L of the tube, stationary waves are formed.

(a) Explain how stationary waves are formed in the tube.

....

....

....[2]

(b) The length L is adjusted between 0.200 m and 1.00 m.

(i) Calculate two values of L for which stationary waves are formed.

L = ... m and L = ... m [2]

(ii) On Fig. 6.2, label the positions of the antinodes with an **A** and the nodes with an **N** for the least value of L for which a stationary wave is formed.

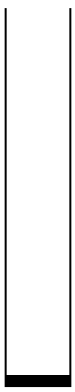


Fig. 6.2

[1]

