**1** 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**.

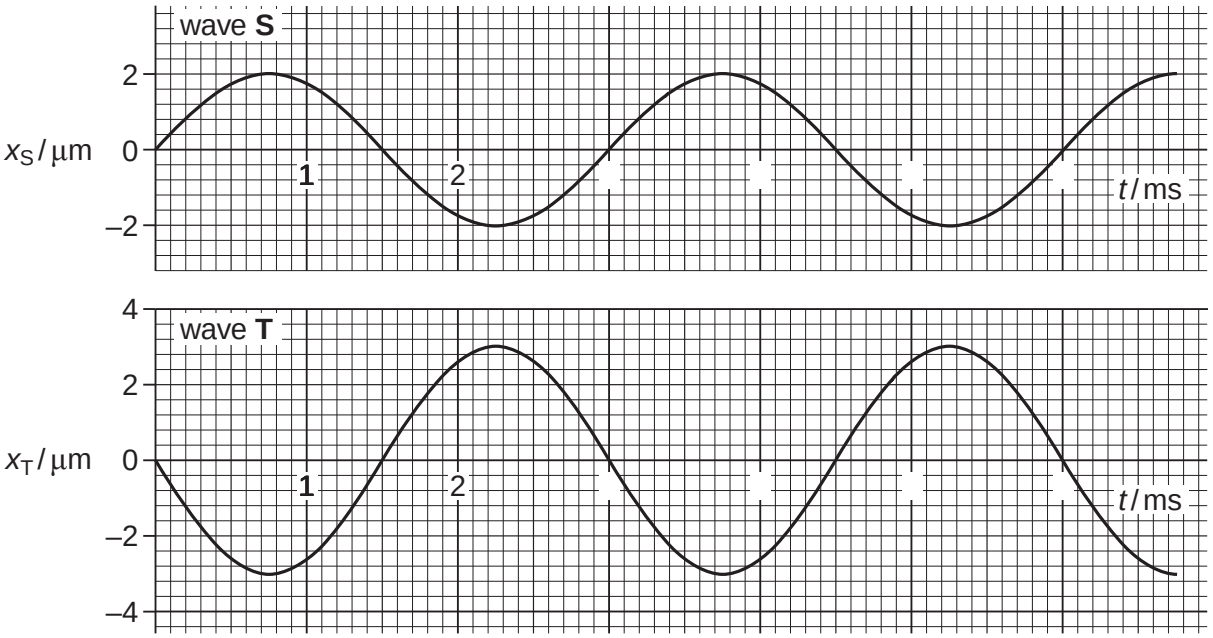


**Fig. 4.1**

**(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 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 $2.25\,I$.

**[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]**

**2** **(a)** **(i)** Define the terms *wavelength, frequency* and *speed* used to describe a progressive wave.

*wavelength*, $\lambda$ .....

.....

*frequency, f* .....

.....

*speed, v* .....

..... **[3]**

**(ii)** Hence derive the wave equation $v = f\lambda$ which relates these terms together.

**[2]**

**(b)** **(i)** Explain what is meant by *infra-red radiation*.

.....

.....

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

**(ii)** For infra-red radiation emitted at a frequency of $6.7 \times 10^{13}$ Hz, calculate

**1** its wavelength

wavelength = …… m **[2]**

**2** its period of oscillation.

period = …… s **[2]**

**(iii)** Infra-red radiation is absorbed by molecular ions in a crystal causing them to vibrate at a frequency of $6.7 \times 10^{13}$ Hz. The amplitude of oscillation of the ions is $8.0 \times 10^{-12}$ m.

On the grid of Fig. 5.1 sketch a graph showing the variation with time of the displacement of an ion.

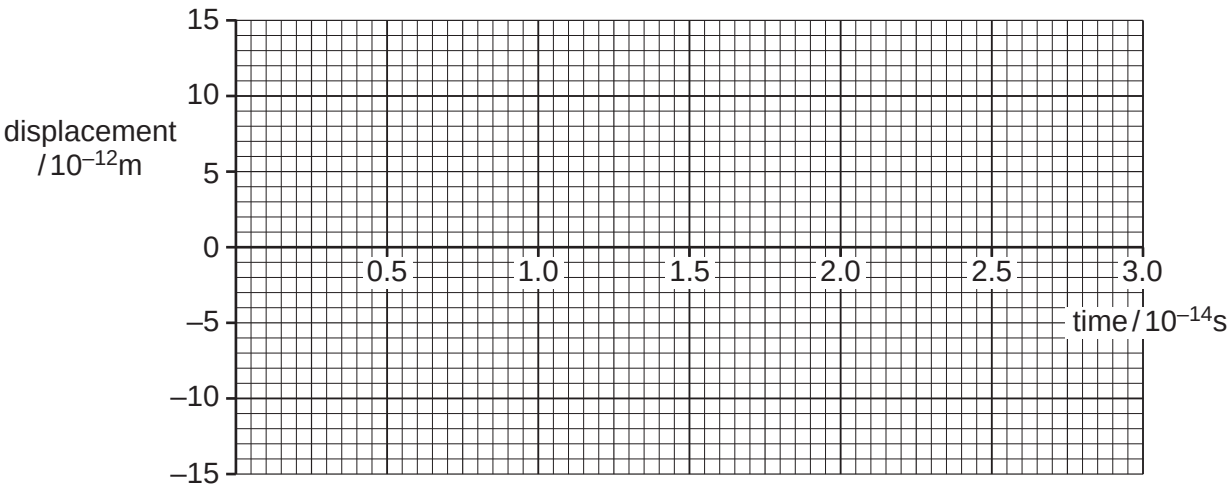


**Fig. 5.1**

**[3]**

**[Total: 14]**

**3** **(a)** Interference of waves from two sources can only be observed when the waves are coherent.

Explain the meaning of

**(i)** *interference*

.....

.....

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

**(ii)** *coherence*.

.....

..... **[1]**

**(b)** Fig. 6.1 shows two microwave transmitters **A** and **B** 0.20 m apart. The transmitters emit microwaves of equal amplitude in phase and of wavelength 30 mm. A detector, moved along the line **PQ** at a distance of 5.0 m from **AB**, detects regions of high and low intensity forming an interference pattern.

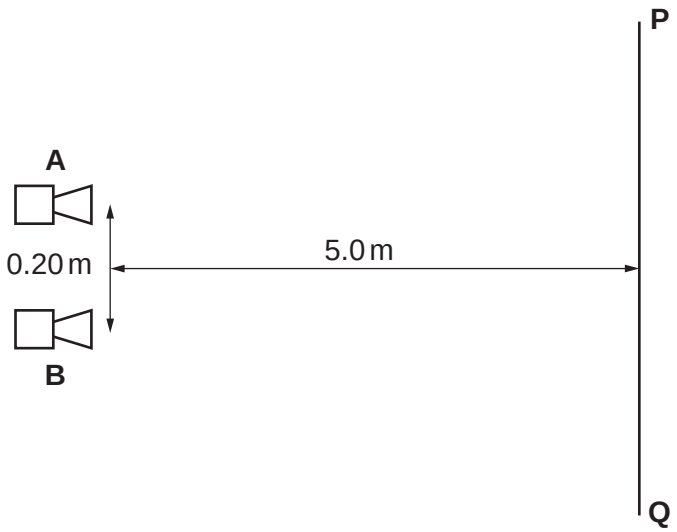


**Fig. 6.1**

**(i)** Use the ideas of path difference or phase difference to explain how the interference pattern is formed.

.....

.....

.....

.....

.....

..... **[3]**

**(ii)** Calculate the separation between one region of high intensity and the next along the line **PQ**.

separation = …… m **[2]**

**(iii)** State the effect, if any, on the position and intensity of the maxima when each of the following changes is made, separately, to the experiment.

**1** The amplitude of the transmitted waves is doubled.

.....

.....

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

**2** The separation between the transmitters is halved.

.....

.....

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

**3** The phase of transmitter **A** is reversed so that there is now a phase difference of 180° between the waves from **A** and **B**.

.....

.....

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

**[Total: 14]**