1 **(a)** Fig. 4.1 shows a section of a uniform string under tension at one instant of time. A progressive wave of wavelength 80 cm is moving along the string from left to right. At the instant shown, the displacement of the string is zero at the point opposite the zero mark on the scale beneath the string.

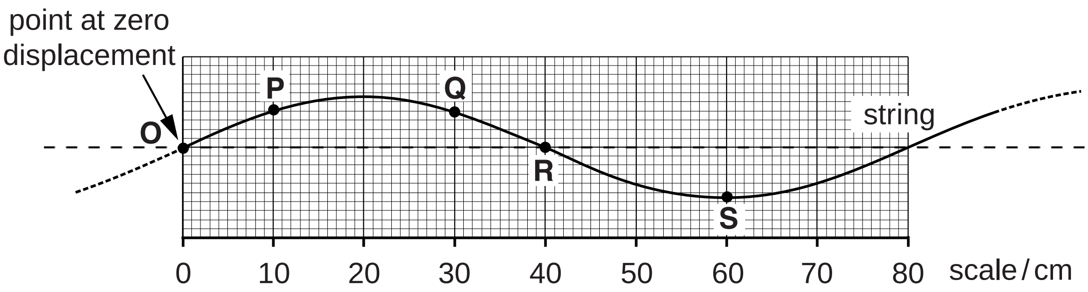

Fig. 4.1

Four points **P**, **Q**, **R** and **S** at 10, 30, 40 and 60 cm respectively, are marked on the string. The oscillatory motion of each point can be described in terms of amplitude, frequency and phase difference from **O**.

(i) State the meaning of each of the terms

1 *amplitude*

....

....

2 *frequency*

....

....

3 *phase difference*.

....

....

[3]

(ii) Describe using these three terms how the motion of points **P**, **Q**, **R** and **S**

1 is similar,

....

....

2 is different.

....

....

[2]

(b) Fig. 4.2 shows the same section of string now held under tension between a clamp and a pulley, 80 cm apart. A mechanical oscillator is attached to the string close to the clamped end. The frequency of the mechanical oscillator is varied until the stationary wave shown is set up between the clamp and the pulley. The same four points as in Fig. 4.1 are marked on the string.

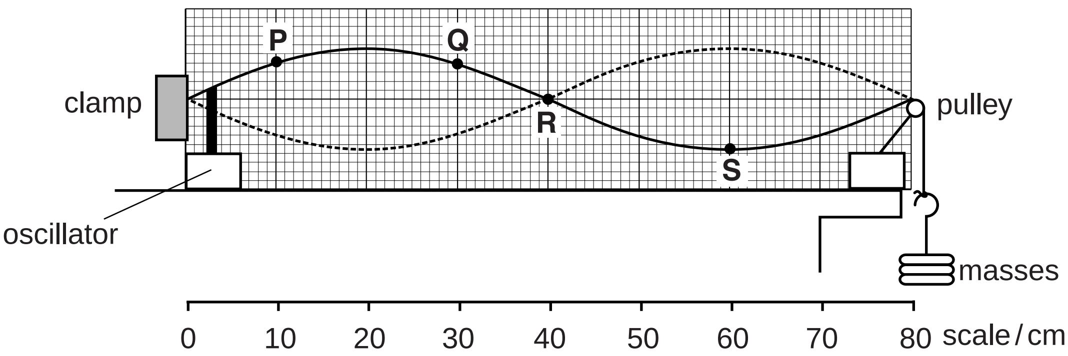

Fig. 4.2

(i) Describe how a stationary wave is different from a progressive wave.

....

....

....

....

.... **[2]**

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

....

....

....

....

....

.... **[3]**

(iii) Describe, using the terms amplitude, frequency and phase difference, how the motions of the points **P**, **Q** and **S**

1 are similar,

....

....

2 are different.

....

....
[3]

(iv) In Fig. 4.2 the frequency of oscillation is 30 Hz. State, with a reason, the lowest frequency of oscillation of the string at which the motions of all of the points **P**, **Q**, **R** and **S** are

1 in phase,

....

....

2 all at rest.

....

....
[4]

2 Fig. 5.1 shows two microwave transmitters **A** and **B** 0.20 m apart. The transmitters emit microwaves of frequency 10 GHz, of equal amplitude and in phase. A microwave detector is placed at **O** a distance of 4.0 m from **AB**.

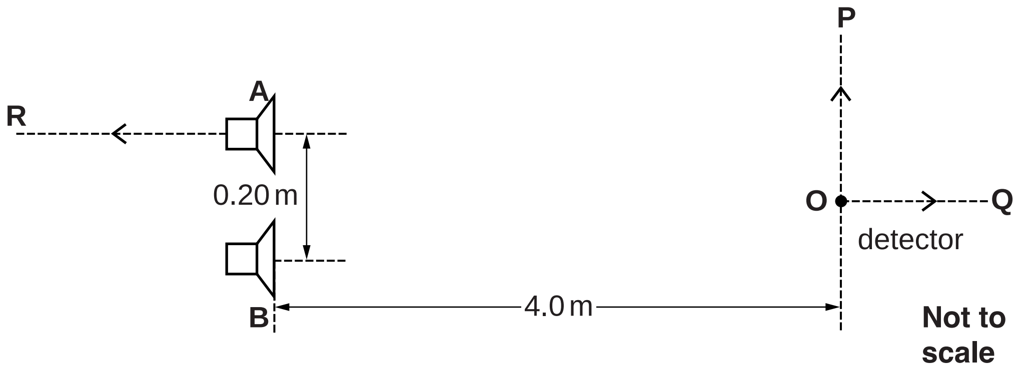

Fig. 5.1

(a) Interference of the waves from the two transmitters is detected only when the transmitters are coherent. Explain the meaning of

(i) *interference*

....

....

.... **[2]**

(ii) *coherent.*

....

.... **[1]**

(b) The length of the detector aerial is half a wavelength. Calculate the length of the aerial.

Show your working.

aerial length = ... m **[2]**

(c) (i) 1 Explain why the amplitude of the detected signal changes when the detector is moved in the direction **OP**.

....

....

....

.... **[2]**

2 Calculate the distance between adjacent **maximum** and **minimum** signals.

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

(ii) Explain why the amplitude of the detected signal changes when the detector is moved in the direction **OQ**.

....

....

....

.... **[2]**

(iii) Explain why the amplitude of the detected signal decreases to a minimum before increasing again as transmitter **A** is moved a small distance in the direction **AR** with the detector fixed at **O**. Calculate the distance **A** is moved to cause this minimum signal at **O**.

....

....

....

....

....

....

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

(d) State, with a reason, the effect on the intensity of the signal detected at **O** when each of the following changes is made.

(i) The amplitude of the waves emitted from **A** and **B** is doubled.

....

....

.... **[2]**

(ii) The detector **O** is rotated 90° about the axis through **OQ**.

....

....

....

....

.... **[3]**

3 Fig. 5.1 shows two loudspeakers **S** and **T** connected to a signal generator, emitting sound of a single frequency but with different amplitudes. A person walks in the direction from **O** to **Q**. The line **OQ** is at a distance D from the loudspeakers.

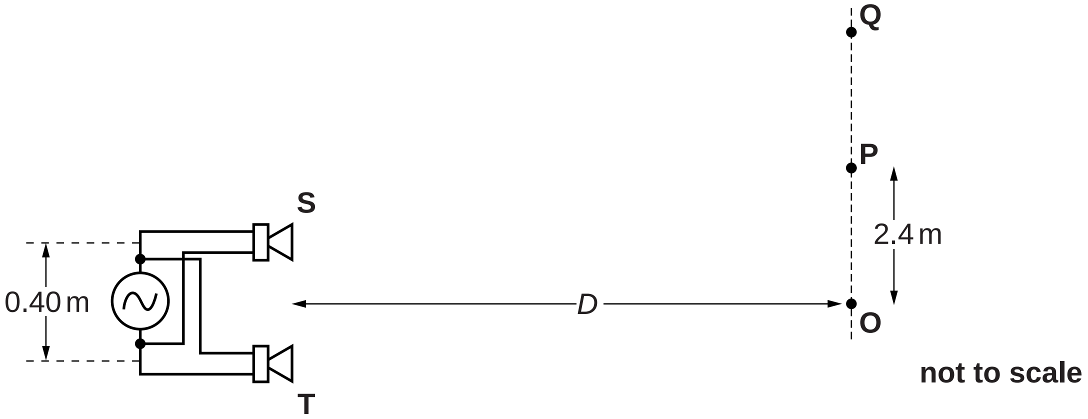

Fig. 5.1

The sound waves emitted individually by **S** and **T** have displacements x_S and x_T at the point **P**. Fig. 5.2 shows the variation with time t of each of these displacements. Note that the amplitude of the wave from **T** is twice that of the wave from **S**.

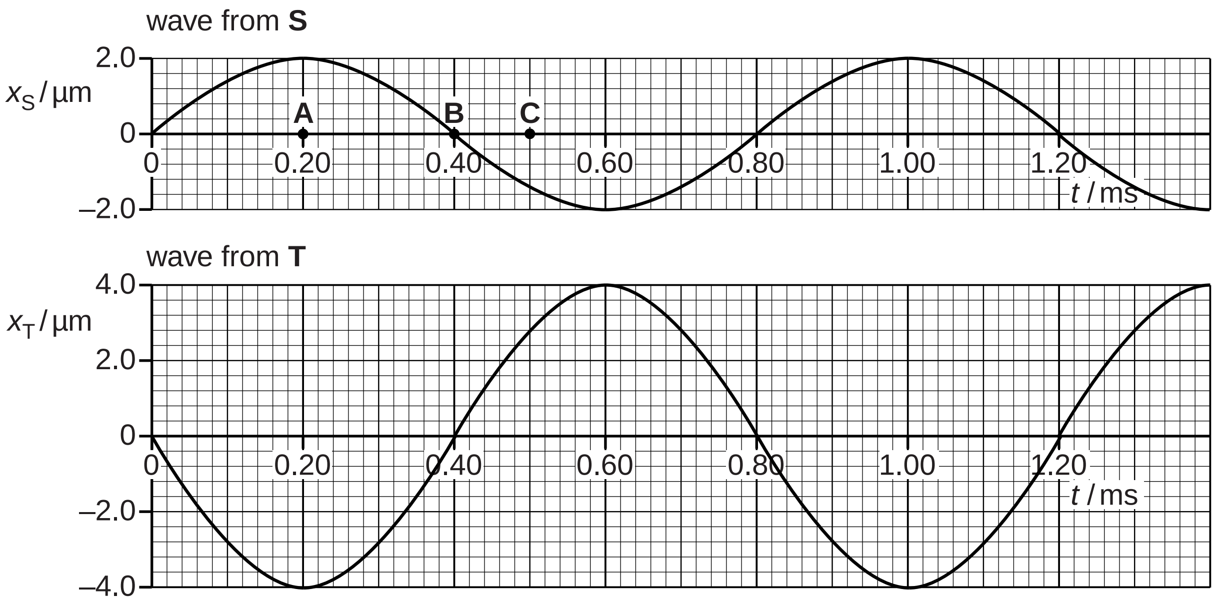

Fig. 5.2

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

....

.... **[1]**

(b) Explain why the sound heard at **P** will be of minimum but not zero intensity.

....

....

....

.... **[2]**

(c) State the phase difference between the oscillation at time **A**, labelled on the *t*–axis of the x_S against *t* curve in Fig. 5.2, and the oscillation

(i) at time **B** ....

(ii) at time **C** .... **[2]**

(d) (i) Calculate the wavelength λ of the sound waves emitted from the loudspeakers.

speed of sound in air = 340 m s^{-1}

λ = ... m **[3]**

(ii) Maximum intensity of sound is heard at point **O**. The loudspeakers are 0.40 m apart and the distance **OP** is 2.4 m. **P** is the position of the first minimum.
Calculate the distance *D* from the loudspeakers to the line **OQ**. Assume that the equation used for the interference of light from a double-slit also applies for the sound from these two loudspeakers.

D = ... m **[3]**

(e) (i) Explain the term *intensity*.

....

.... **[1]**

(ii) The intensity of the sound at point **P**, the minimum, is $4.0 \times 10^{-6}\,W\,m^{-2}$. Use data from Fig. 5.2 to calculate the maximum intensity of sound, at point **O**.

maximum intensity = ... $W\,m^{-2}$ **[3]**

[Total: 15]