1)

(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.

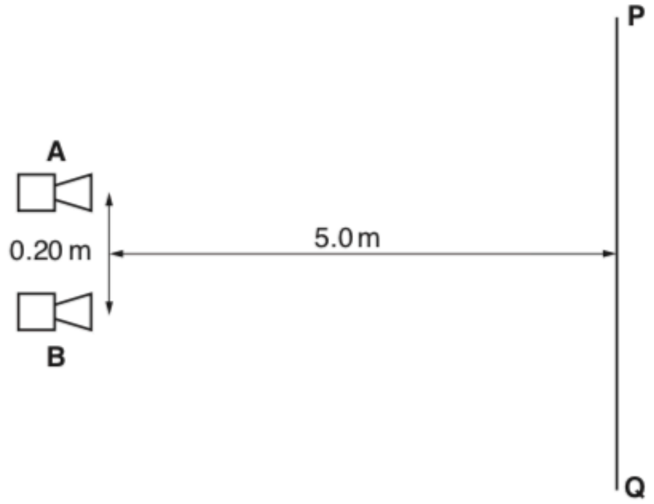

Fig. 6.1

(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]

2)

(a) Explain what is meant by a *progressive wave*.

[2]

(b) Describe how a *transverse* wave differs from a *longitudinal* wave.

[2]

(c) **(i)** Explain what is meant by *diffraction* of a wave.

[1]

(ii) Describe how you would demonstrate that a sound wave of wavelength 0.10 m emitted from a loudspeaker can be diffracted.

In your answer you should make clear how your observations show that diffraction is occurring.

[4]

(d) Fig. 4.1 shows two loudspeakers connected to a signal generator, set to a frequency of 1.2 kHz. A person walks in the direction **P** to **Q** at a distance of 3.0 m from the loudspeakers.

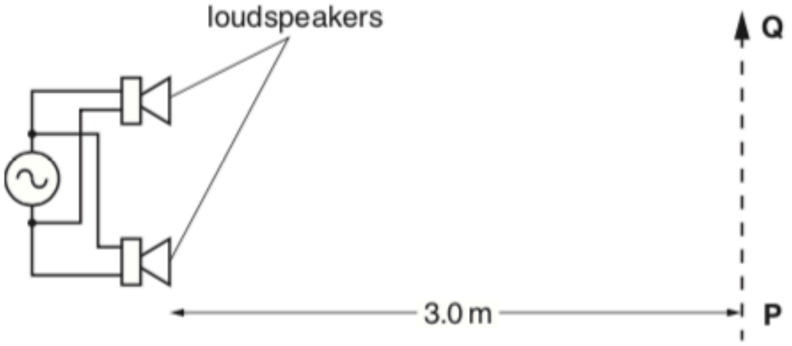

Fig. 4.1

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

speed of sound in air = $340\,\text{m}\,\text{s}^{-1}$

λ = ... m **[2]**

(ii) Explain, either in terms of path difference or phase difference, why the intensity of the sound heard varies as the person moves along **PQ**.

....

....

....

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....

....

.... **[3]**

(iii) The distance x between adjacent positions of maximum sound is 0.50 m. Calculate the separation a between the loudspeakers. Assume that the equation used for the interference of light also applies to sound.

a = ... m **[2]**

(iv) The connections to one of the loudspeakers are reversed. Describe the similarities and differences in what the person hears.

....

....

....

....

....

.... **[2]**

[Total: 18]

3)

This question is about measuring the wavelength of the yellow light from a sodium lamp.

(a) A beam of light from a sodium lamp passes through a pair of narrow slits $\mathbf{S_1}$ and $\mathbf{S_2}$ producing a pattern on a screen. See Fig. 6.1. The pattern on the screen consists of regularly spaced bright and dark lines, called fringes. See Fig. 6.2.

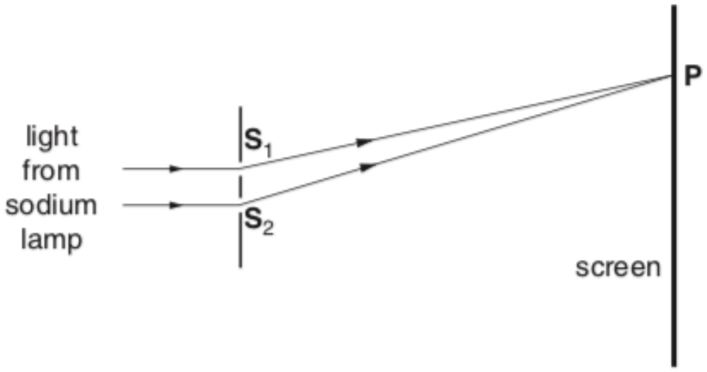

Fig. 6.1

(i) State and explain the conditions necessary for the light from the two slits $\mathbf{S_1}$ and $\mathbf{S_2}$ to produce a visible pattern on the screen.

....

....

....

....

....

....

.... **[3]**

(ii) Using the ideas of wave superposition, explain the existence of the bright and the dark fringes. In your answer state the condition for a bright fringe to appear on the screen at **P** in Fig. 6.1 and the condition for a dark fringe to appear at **P**.

....

....

....

....

....

....

....

.... **[4]**

(b) Fig. 6.2 shows the central part of the fringe pattern on the screen at 1.5 m from the slits $\mathbf{S}_1$ and $\mathbf{S}_2$ which are 0.60 mm apart.

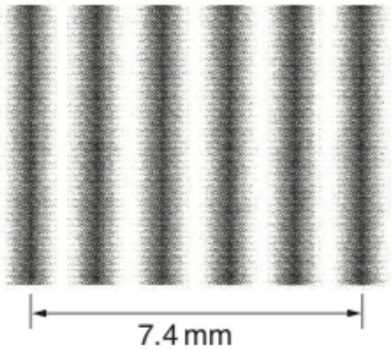

Fig. 6.2

Calculate

(i) the fringe separation, that is, the separation x between adjacent dark lines

x = ... m **[1]**

(ii) the wavelength λ of the yellow light.

λ = ... m **[3]**

(c) One of the two slits is covered up. Describe and explain how the pattern of light on the screen is different from that of Fig. 6.2.

....

....

....

....

....

.... **[3]**

[Total: 14]

4)

This question is about the Young double slit experiment. See Fig. 7.1. The fringe pattern seen on the screen is shown to the right.

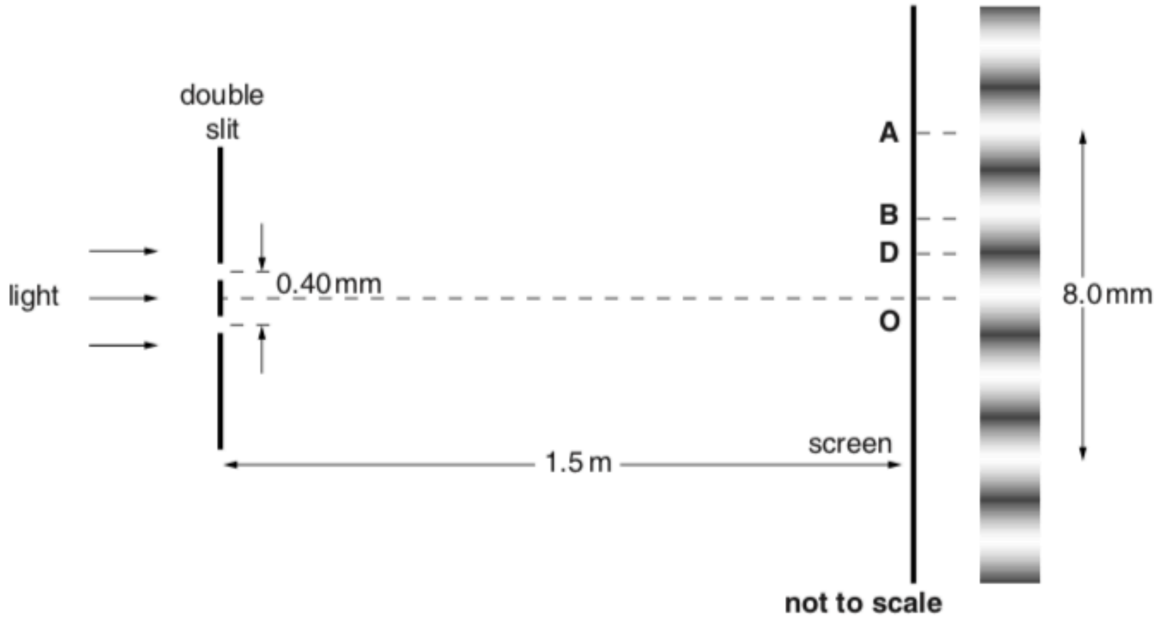

Fig. 7.1

Two parallel clear lines are scratched on a darkened glass slide 0.40 mm apart. When a beam of monochromatic visible light is shone through these slits, interference fringes are observed on a screen placed 1.5 m from the slide. The fringe at point **B** is bright and the fringe at point **D** is dark.

(a) Explain why this arrangement with two slits is used to produce visible fringes on the screen rather than two separate identical light sources.

....

....

.... **[2]**

(b) State the **phase difference** between the light waves from the two slits that meet on the screen in Fig. 7.1 at point

D ....

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

(c) **(i)** Use Fig. 7.1 to calculate the separation of adjacent bright fringes, the distance between **O** and **B**.

fringe separation = ... m **[1]**

(ii) Show that the wavelength λ of the monochromatic light is about 5×10^{-7} m.

[3]

(d) Calculate the **path difference**, in nanometres, between the light waves from the two slits that meet on the screen in Fig. 7.1 at point **A**.

path difference = ... nm **[2]**

(e) The energy level diagram of Fig. 7.2 is for the atoms emitting photons in the light source. Electron transitions between the three levels shown produce three photons of different wavelength. The energy E of an electron bound to an atom is negative.

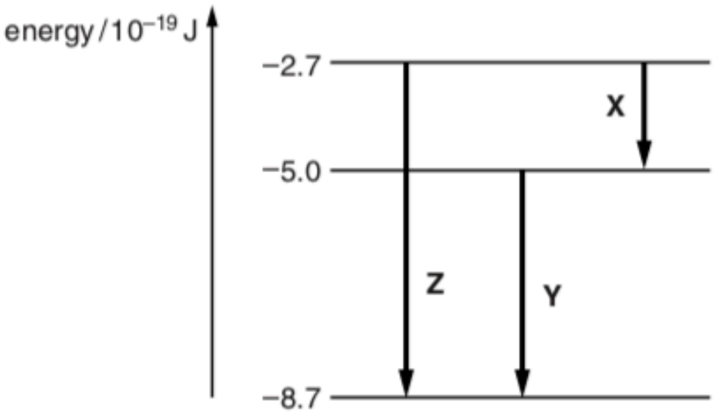

Fig. 7.2

(i) Use data from Fig. 7.2 to justify that the arrow labelled **Y** produces the photons of wavelength about 5×10^{-7} m used in the interference experiment.

[4]

(ii) Neither of the photons shown by the other transitions can be used for the experiment because they are not visible. State in which region of the electromagnetic spectrum each photon is produced, by the other transitions, **X** and **Z**.

X ....

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

[Total: 16]

5)

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.

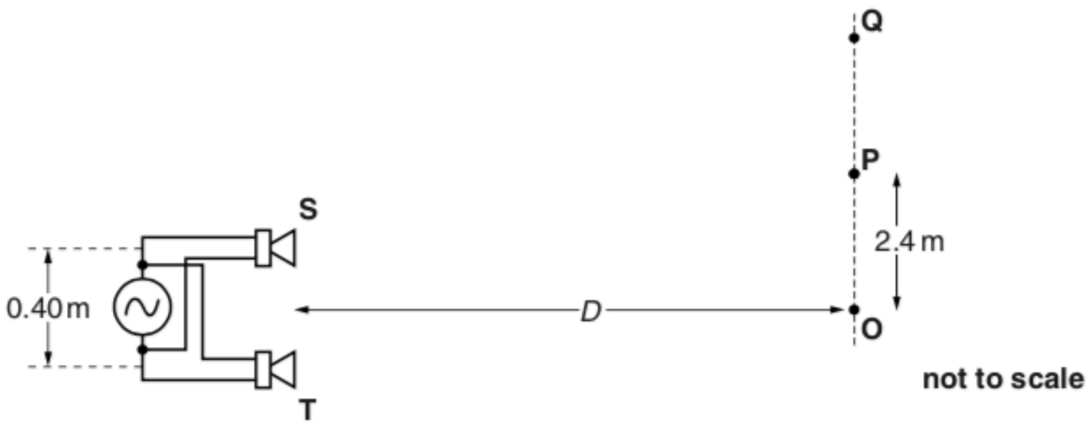

Fig. 5.1

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**.

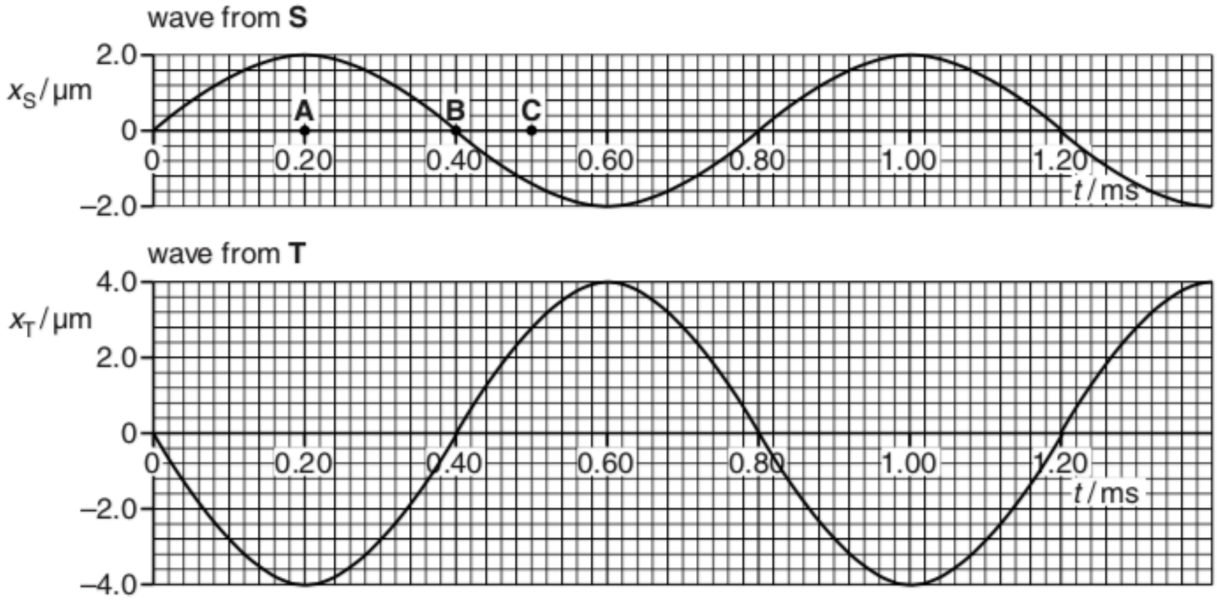

Fig. 5.2

(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 = $340\,\text{m}\,\text{s}^{-1}$

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 $4.0 \times 10^{-6}\,\mathrm{W\,m^{-2}}$. Use data from Fig. 5.2 to calculate the maximum intensity of sound, at point **O**.

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

[Total: 15]

6)

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**.

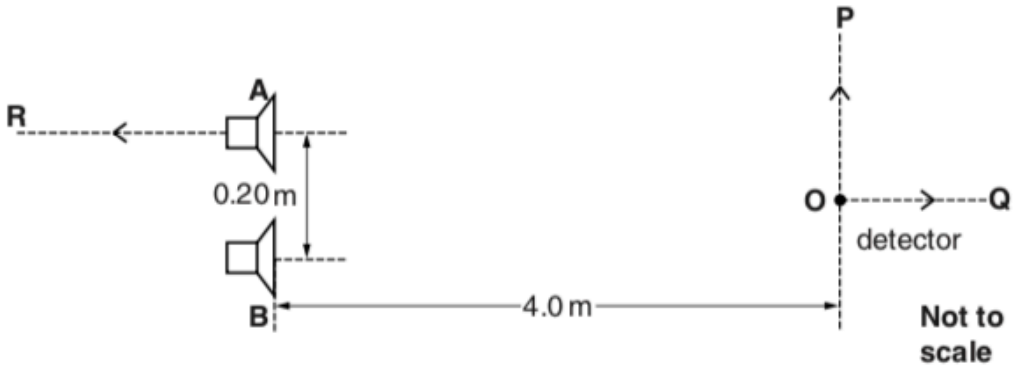

Fig. 5.1

(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]**