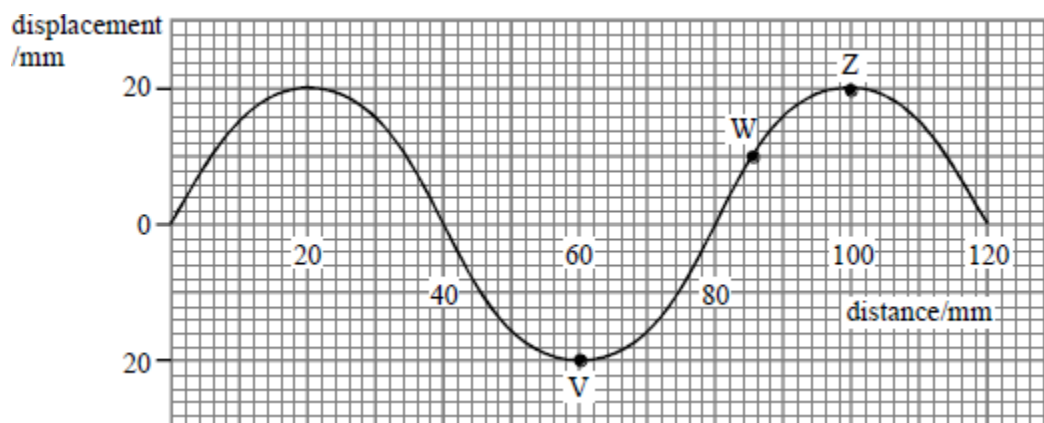


1

The graph shows the variation of displacement of the particles with distance along a stationary transverse wave at time $t = 0$ when the displacement of the particles is greatest. The period of the vibrations causing the wave is 0.040 s .



(a) Using the same axes,

- (i) draw the appearance of the wave at $t = 0.010\text{ s}$, labelling this graph B,
- (ii) draw the appearance of the wave at $t = 0.020\text{ s}$, labelling this graph C,
- (iii) show an antinode labelled A and a node labelled N.

(3)

(b) (i) Describe the motion of the particle at V, giving its frequency and amplitude.

- (ii) State the amplitude of the particle at W and its phase relations with the particle at V and the particle at Z.

(6)

(Total 9 marks)

2

A light source emits light which is a mixture of two wavelengths, λ_1 and λ_2 . When the light is incident on a diffraction grating it is found that the fifth order of light of wavelength λ_1 occurs at the same angle as the fourth order for light of wavelength λ_2 . If λ_1 is 480 nm what is λ_2 ?

A 400 nm



B 480 nm



C 600 nm



D 750 nm

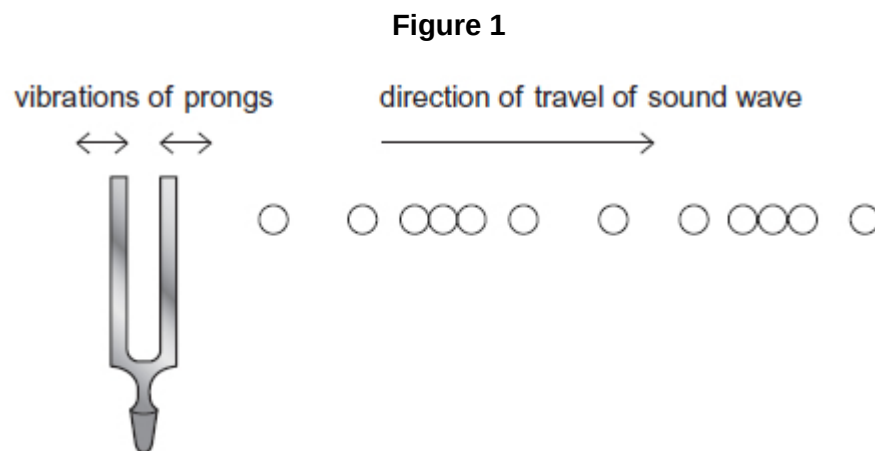


(Total 1 mark)

3

Musicians can use tuning forks to tune their instruments.
A tuning fork produces a specific frequency when it vibrates.

Figure 1 shows a tuning fork vibrating in air at a single instant in time.
The circles represent the positions of air particles in the sound wave.



(a) The tuning fork emits a wave that has a frequency of 0.51 kHz.

(i) State the meaning of the term frequency of a wave.

(1)

- (ii) Air particles vibrate in different phases in the direction in which the wave is travelling.

Calculate the minimum separation of particles that vibrate 180° out of phase.

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

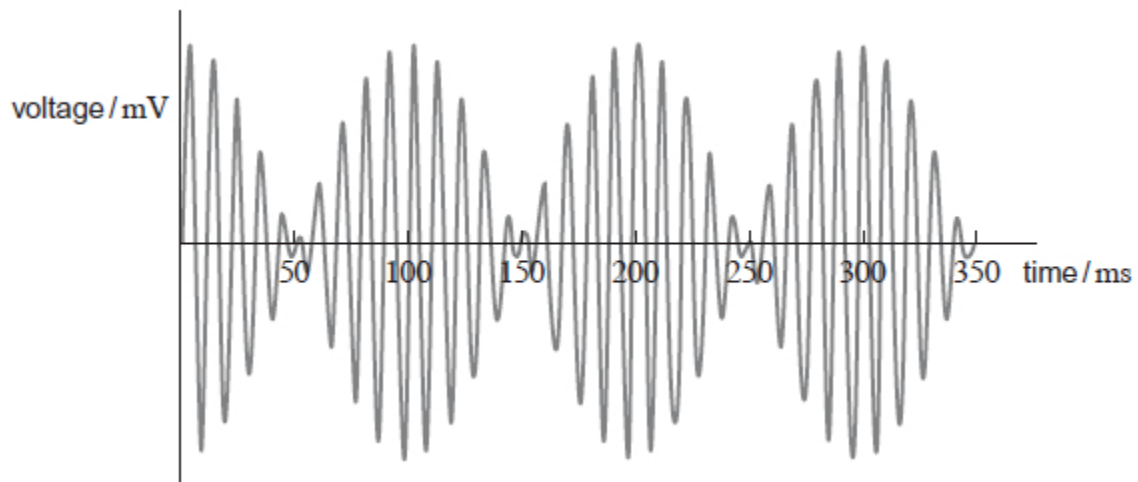
minimum separation _____ m

(3)

- (b) A student sets a tuning fork of lower frequency vibrating at the same time as the 0.51 kHz tuning fork in part (a).

The student detects the resultant sound wave with a microphone. The variation with time of the voltage generated by the microphone is shown in **Figure 2**.

Figure 2



- (i) Explain why the two tuning forks are **not** coherent sources of sound waves.

(2)

- (ii) Explain why the resultant sound has a minimum amplitude at 50 ms.

(3)

- (iii) Calculate the frequency of the tuning fork that emits the lower frequency.

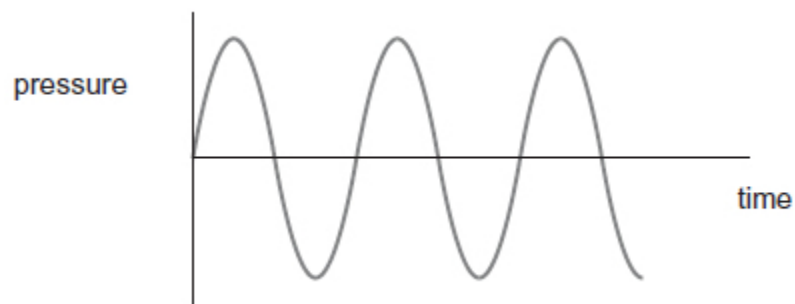
frequency _____ Hz

(3)

- (c) A signal generator connected to a loudspeaker produces a sinusoidal sound wave with a frequency of 440 Hz.

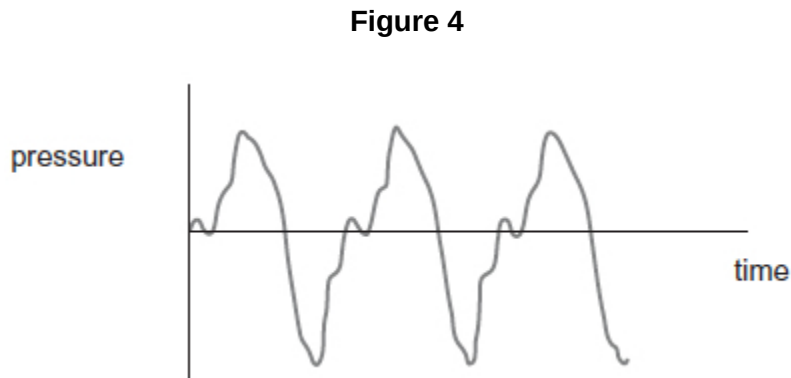
The variation in air pressure with time for this sound is shown in **Figure 3**.

Figure 3



A violin string has a fundamental frequency (first harmonic) of 440 Hz.

Figure 4 shows the variation in air pressure with time for the sound created by the violin string.



- (i) The two sounds have the same pitch but sound different.

What term describes the difference between the sounds heard?

Tick (✓) the correct answer.

Frequency modulation

☐

Octaves

☐

Path difference

☐

Quality

☐

(1)

- (ii) The complex sound in **Figure 4** can be electronically synthesised.

Describe the process of electronically synthesising this sound.

(3)

(Total 16 marks)

4

Two loudspeakers emit sound waves.

Which line in the table gives the correct frequency condition and the correct phase condition for the waves from the loudspeakers to be coherent?

	Frequency condition	Phase condition	
A	same frequency	variable phase difference	☐
B	constant frequency difference	constant phase difference	☐
C	constant frequency difference	in phase	☐
D	same frequency	constant phase difference	☐

(Total 1 mark)

5

(a) State what is meant by *coherent sources* of light.

(2)

(b)

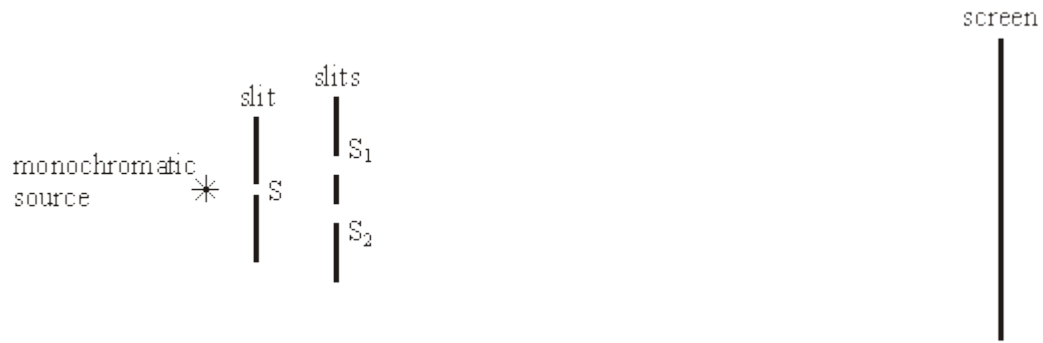


Figure 1

Young's fringes are produced on the screen from the monochromatic source by the arrangement shown in **Figure 1**.

You may be awarded marks for the quality of written communication in your answers.

(i) Explain why slit S should be narrow.

(ii) Why do slits S_1 and S_2 act as coherent sources?

(4)

- (c) The pattern on the screen may be represented as a graph of intensity against position on the screen. The central fringe is shown on the graph in **Figure 2**. Complete this graph to represent the rest of the pattern by drawing on **Figure 2**.

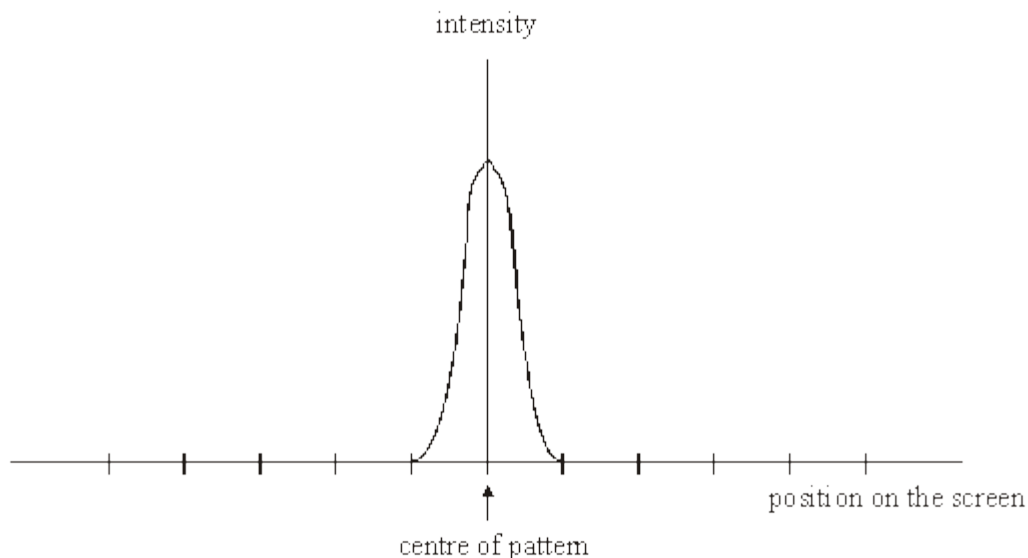


Figure 2

(2)

(Total 8 marks)

- 6** A laser emits light of wavelength 6.3×10^{-7} m and is used to illuminate a double slit which has a separation of 2.4×10^{-4} m. Interference fringes are observed 4.2 m from the slits.

- (a) Calculate the fringe separation.

(2)

- (b) The double slit acts as a pair of *coherent* sources. Explain what is meant by *coherent* sources.

(2)

- (c) The diagram shows the light from the slits, S_1 and S_2 , meeting at **P** where the first dark fringe is observed.



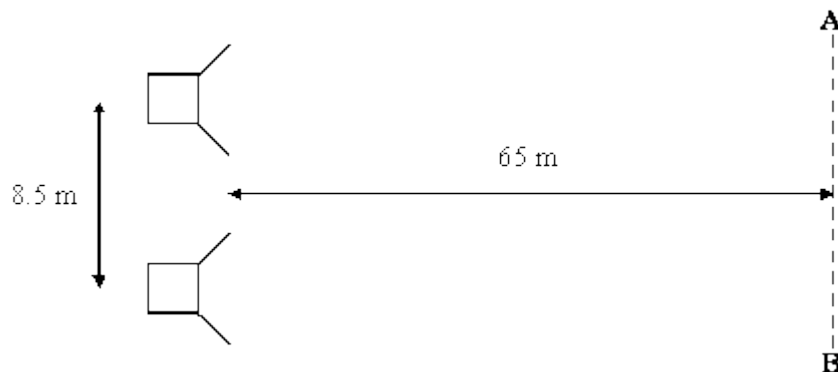
Explain why a dark fringe is observed at **P**.

(3)

(Total 7 marks)

7

The diagram below shows an arrangement used to demonstrate the interference of sound waves. The two loudspeakers act as *coherent sources* of sound.



- (a) Explain what is meant by the term coherent sources.

(2)

- (b) In the diagram, the loudspeakers are separated by 8.5 m and are emitting sound of wavelength 0.77 m. When a sound engineer walks along the line **AB**, 65 m from the loudspeakers, he observes a regular rise and fall in the sound intensity.

- (i) Explain this observation.

(2)

- (ii) Calculate the distance moved along **AB** between two consecutive maxima of sound.

Distance moved _____

(2)

(Total 6 marks)

8

A progressive wave of frequency 150 Hz travels along a stretched string at a speed of 30 m s^{-1} .

What is the phase difference between two points that are 50 mm apart on the string?

- | | | |
|----------|-------------|-----------------------|
| A | zero | ☐ |
| B | 90° | ☐ |
| C | 180° | ☐ |
| D | 360° | ☐ |

(Total 1 mark)

9

The speed of sound in water is 1500 m s^{-1} . For a sound wave in water having frequency 2500 Hz , what is the minimum distance between two points at which the vibrations are $\frac{\pi}{3}$ rad out of phase?

- A 0.05 m
- B 0.10 m
- C 0.15 m
- D 0.20 m

(Total 1 mark)

10

Two points on a progressive wave differ in phase by $\frac{\pi}{4}$. The distance between them is 0.5 m , and the frequency of the oscillation is 10 Hz . What is the minimum speed of the wave?

- A 0.2 m s^{-1}
- C 10 m s^{-1}
- C 20 m s^{-1}
- D 40 m s^{-1}

(Total 1 mark)

11

What is the phase difference between two points 0.16 m apart on a progressive sound wave of frequency 256 Hz ?

speed of sound = 330 m s^{-1}

- | | | |
|---|-----------------|-----------------------|
| A | $\frac{\pi}{8}$ | ☐ |
| B | $\frac{\pi}{6}$ | ☐ |
| C | $\frac{\pi}{4}$ | ☐ |
| D | $\frac{\pi}{3}$ | ☐ |

(Total 1 mark)

12

A wave of frequency 5 Hz travels at 8 km s^{-1} through a medium. What is the phase difference, in radians, between two points 2 km apart?

A 0

B $\frac{\pi}{2}$

C π

D $\frac{3\pi}{2}$

(Total 1 mark)

13

A progressive wave in a stretched string has a speed of 20 m s^{-1} and a frequency of 100 Hz. What is the phase difference between two points 25 mm apart?

A zero

B $\frac{\pi}{4}$ rad

C $\frac{\pi}{2}$ rad

D π rad

(Total 1 mark)

Mark schemes

1	(a)	(i)	B line along distance axis (1)	
		(ii)	C negative sine wave starting at O (1)	
		(iii)	A, N (1)	(3)
	(b)	(i)	s.h.m. [or particle stationary] (1) amplitude = 20 mm (1)	
			$f = \frac{1}{T} = 25 \text{ Hz or s}^{-1}$ (1)	
		(ii)	10 mm (1) W, V phase difference π [or antiphase or 180°] (1) W, Z in phase (1)	(6)
2	C			[9]
3	(a)	(i)	Number of complete waves passing a point in one second / number of complete waves produced by a source in one second / number of complete vibrations (oscillations) per second / number of compressions passing a fixed point per second	[1]
				1
		(ii)	180° phase difference corresponds to $\frac{1}{2} \lambda$ Use of $v = f\lambda$ with correct powers of 10 0.33 (m)	
				3
	(b)	(i)	Do not have the same frequency do not have a constant phase difference	
				2
		(ii)	Waves meet antiphase Undergo superposition Resulting in destructive interference	
				3
		(iii)	$T = 100 \text{ ms}$ Use of $T = 1 / f$ or beat frequency $(\Delta f) = 10 \text{ Hz}$ 500 (Hz) (allow 510 –their beat frequency)	
				3
	(c)	(i)	Only box ticked: Quality	
				1

- (ii) Add regular alternating voltages together
 With appropriate amplitudes
 Where frequencies of voltages match the harmonics of sound / where frequencies are multiples of 440 Hz

Allow 2 for sampling sound (at twice max frequency) B1

Convert to binary (and replay through D to A converter). B1

3

[16]

4

D

[1]

5

- (a) same wavelength or frequency **(1)**
 (same phase or) constant phase difference **(1)**

2

- (b) (i) narrow slit gives wide diffraction **(1)**
 (to ensure that) both S_1 and S_2 are illuminated **(1)**
- (ii) slit S acts as a point source **(1)**
 S_1 and S_2 are illuminated from same source giving monochromatic/same λ **(1)**
 paths to S_1 and S_2 are of constant length giving constant phase difference **(1)**
 [or $SS_1 = SS_2$ so waves are in phase]

Max 4
 QWC 1

- (c) graph to show:
 maxima of similar intensity to central maximum **(1)**
 [or some decrease in intensity outwards from centre]
 all fringes same width as central fringe **(1)**

2

[8]

6

- (a) $\lambda D / d$ in symbols or numbers

$$1.1 \times 10^{-2}$$

C1

A1

(2)

- (b) same frequency / wavelength.
 constant phase difference

B1

B1

(2)

(c) Reference to out of phase

phase difference is 180° or π / path difference is $\lambda/2$ / explanation of antiphase eg crest meets trough
destructive interference / description of cancelling out

C1

C1

A1

B1

(3)

[7]

7

(a) Constant/zero phase difference/in phase

B1

same frequency/wavelength

B1

2

(b) (i) mention of interference

C1

describes constructive interference **OR** destructive interference **OR** discusses path difference

A1

(ii) $[\lambda D/d]$

$0.77 \times 65 / 8.5$

C1

$= 5.9$ [5.89] m

A1

4

[6]

8

B

[1]

9

B

[1]

10

D

[1]

11

C

[1]

12

B

[1]

