1 Which line, **A** to **D**, in the table gives a correct difference between a progressive wave and a stationary wave?

	progressive wave	**stationary wave**
A	all the particles vibrate	some of the particles do not vibrate
B	none of the particles vibrate with the same amplitude	all the particles vibrate with the same amplitude
C	all the particles vibrate in phase with each other	none of the particles vibrate in phase with each other
D	some of the particles do not vibrate	all the particles vibrate in phase with each other

(Total 1 mark)

2 Which of the following statements about the behaviour of waves is **incorrect**?

A All waves can be diffracted.

B All waves can be made to undergo superposition.

C All waves can be refracted.

D All waves can be polarised.

(Total 1 mark)

3 Stationary waves are set up on a length of rope fixed at both ends. Which one of the following statements is true?

A Between adjacent nodes, particles of the rope vibrate in phase with each other.

B The mid point of the rope is always stationary.

C Nodes need not necessarily be present at each end of the rope.

D Particles of the rope at adjacent antinodes always move in the same direction.

(Total 1 mark)

4 Which one of the following statements about stationary waves is true?

A Particles between adjacent nodes all have the same amplitude.

B Particles between adjacent nodes are out of phase with each other.

C Particles immediately on either side of a node are moving in opposite directions.

D There is a minimum disturbance of the medium at an antinode.

(Total 1 mark)

5 The frequency of the first harmonic of a standing wave on a wire is f. The length of the wire and tension in the wire are both doubled.

What is the frequency of the first harmonic as a result?

A $\frac{f}{\sqrt{2}}$ ☐

B f ☐

C $\sqrt{2}f$ ☐

D $2f$ ☐

(Total 1 mark)

6 Which one of the following statements about stationary waves is true?

A Particles between adjacent nodes all have the same amplitude.

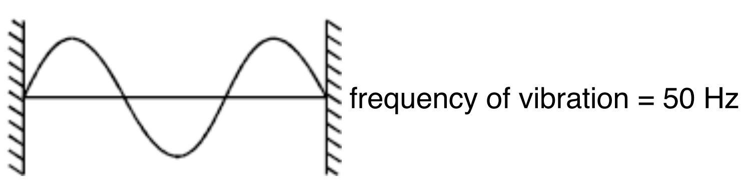
B Particles between adjacent nodes are out of phase with each other.

C Particles immediately on either side of a node are moving in opposite directions.

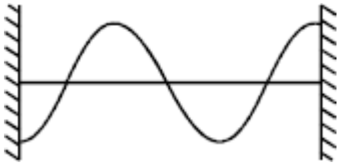
D There is minimum disturbance of the medium at an antinode.

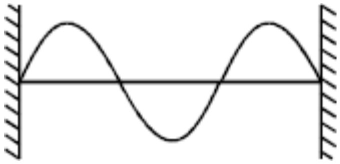
(Total 1 mark)

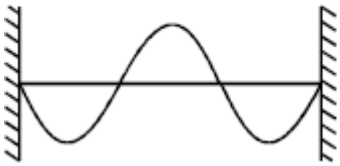
7

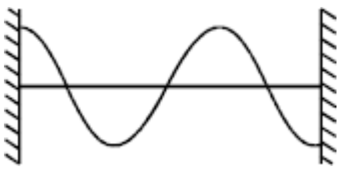


The diagram above shows a stationary wave on a stretched string at a time t = 0. Which one of the diagrams, **A** to **D**, correctly shows the position of the string at a time t = 0.010 s?

A 

B 

C 

D 

(Total 1 mark)

8 A uniform wire fixed at both ends is vibrating in its fundamental mode. Which one of the following statements is **not** correct for all the vibrating particles?

A They vibrate in phase.

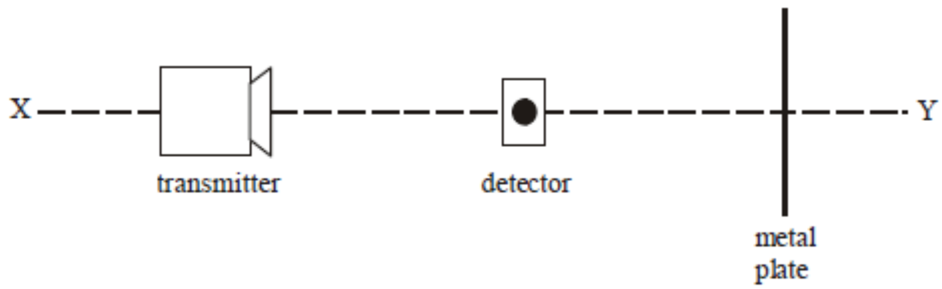
B They vibrate with the same amplitude.

C They vibrate with the same frequency.

D They vibrate at right angles to the wire.

(Total 1 mark)

9 A microwave transmitter is used to direct microwaves of wavelength 30 mm along a line XY. A metal plate is positioned at right angles to XY with its mid-point on the line, as shown.



When a detector is moved gradually along XY, its reading alternates between maxima and minima. Which one of the following statements is **not** correct?

A The distance between two minima could be 15 mm.

B The distance between two maxima could be 30 mm.

C The distance between a minimum and a maximum could be 30 mm.

D The distance between a minimum and a maximum could be 37.5 mm.

(Total 1 mark)

10 A stationary wave is formed by two identical waves of frequency 300 Hz travelling in opposite directions along the same line. If the distance between adjacent nodes is 0.60 m, what is the speed of each wave?

A 180 m s^{-1}

B 250 m s^{-1+}

C 360 m s^{-1}

D 500 m s^{-1}

(Total 1 mark)

11 Which of the following is correct for a stationary wave?

A Between two nodes the amplitude of the wave is constant.

B The two waves producing the stationary wave must always be 180° out of phase.

C The separation of the nodes for the second harmonic is double the separation of nodes for the first harmonic.

D Between two nodes all parts of the wave vibrate in phase.

(Total 1 mark)

12 Two radio transmitters emit waves at a frequency of 1.4 MHz. A stationary wave is set up between the two transmitters due to the superposition of the radio waves.

What is the minimum distance between two nodes in the stationary wave?

A 107 m ○

B 214 m ○

C 428 m ○

D 857 m ○

(Total 1 mark)

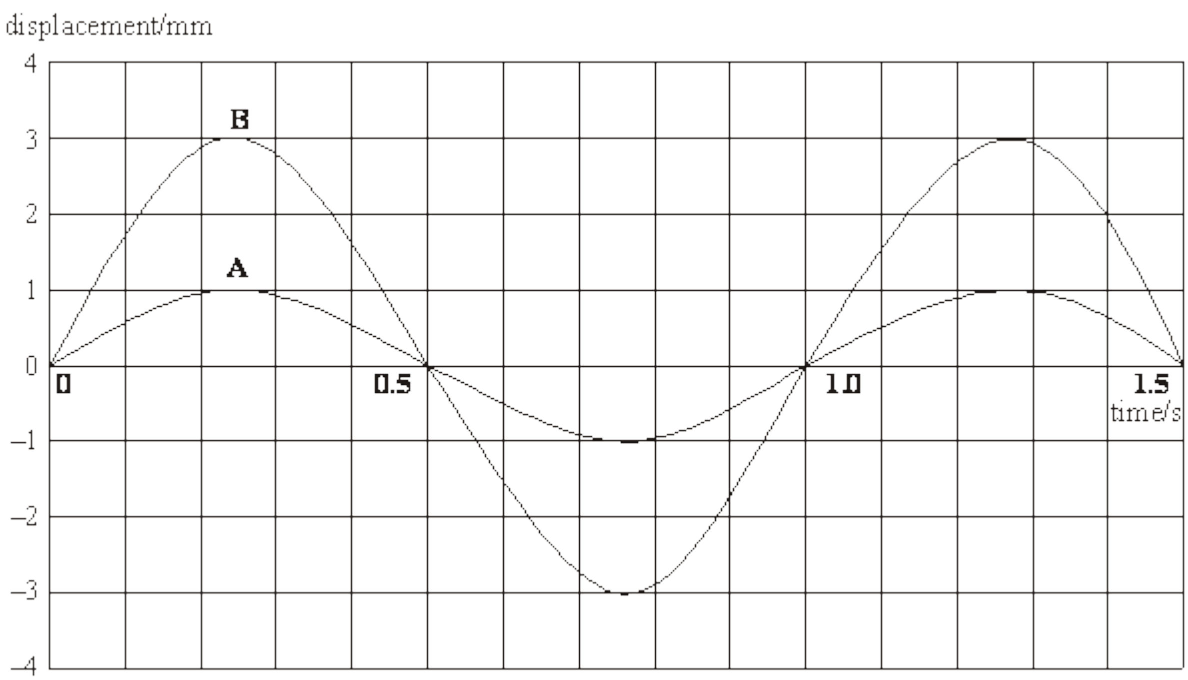
13 State two factors that affect the fundamental frequency of a vibrating stretched string.

Factor 1 ______________________________

Factor 2 ______________________________

(Total 2 marks)

14 The figure below shows a graph of displacement against time for two waves **A** and **B.** These waves meet in phase and add to form a resultant wave.



(a) State the amplitude of the resultant wave

____

(1)

(b) Calculate the ratio

intensity of wave **B** : intensity of wave **A**.

(2)
(Total 3 marks)

15 Explain the differences between an undamped progressive transverse wave and a stationary transverse wave, in terms of (a) amplitude, (b) phase and (c) energy transfer.

(a) amplitude

progressive wave ____

____

stationary wave ____

____

(b) phase

progressive wave ____

____

stationary wave ____

____

(c) energy transfer

progressive wave ____

____

stationary wave ____

____

(Total 5 marks)

16 In the first diagram, **PQ** is a stretched string of length 0.34 m. When it is plucked, it vibrates at a frequency of 440 Hz.

(a) (i) On the second diagram, draw the fundamental mode of vibration for the string.

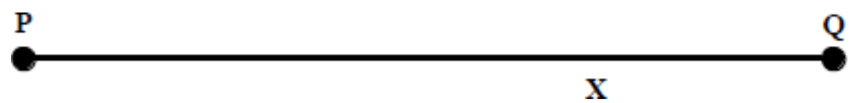
(1)

(ii) State the wavelength of the standing wave produced when the string is plucked.

____

(1)

(iii) The same string is lightly touched at its midpoint and is plucked at the point **X**. Draw the standing wave produced on the diagram below.



(1)

(b) The tension of the string is increased. State the effect this has on the fundamental frequency of vibration of the string.

____

(1)

(Total 4 marks)

17 (a) State the conditions necessary for a stationary wave to be produced.

____

____

____

____

____

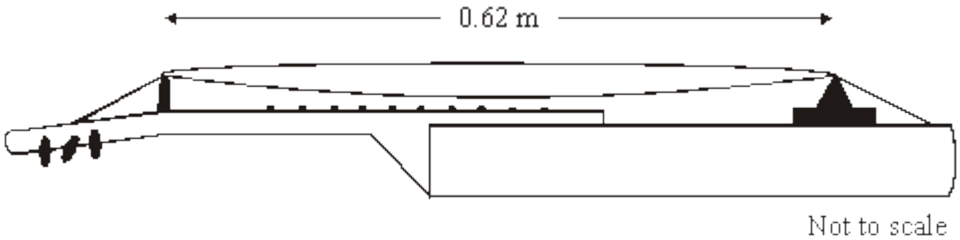
____

____

____

(3)

(b) The diagram shows a stationary wave on a stretched guitar string of length 0.62 m.



The speed of transverse waves along the string is 320 m s^{-1}. Calculate the frequency of the note being played.

Frequency ____________________

(3)

(Total 6 marks)

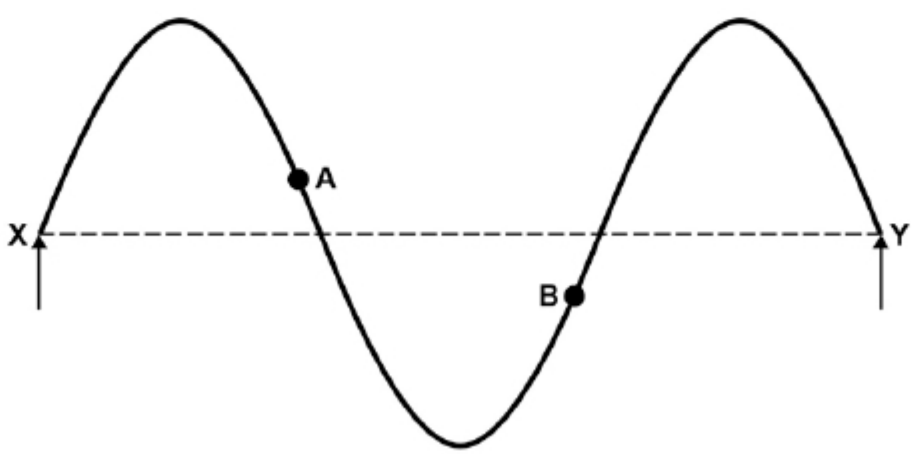
18 A stationary wave is formed on a stretched string. Discuss the formation of this wave. Your answer should include:

- an explanation of how the stationary wave is formed
- a description of the features of the stationary wave
- a description of the processes that produce these features.

The quality of your written communication will be assessed in your answer.

(Total 6 marks)

19 The diagram below shows one position of a guitar string stretched between points **X** and **Y**. The string vibrates at a frequency of 330 Hz.



(a) State the phase relationship between points **A** and **B** on the string.

____

(1)

(b) Points **X** and **Y** are 0.66 m apart.

Calculate the speed of the wave along the string.

speed = ________________ m s^{-1}

(2)

(c) The total mass of the string is 3.1 g and the total length of the string is 0.91 m.

Show that the tension in the string when it is sounding the harmonic shown in the diagram above is about 70 N.

(3)

(d) The string is fixed at one end and wrapped around a tuning peg of radius 3.0 mm at the other. The tuning peg needs to be turned through 3 complete rotations to increase the tension in the string from 0 to 70 N in part **(c)**.

Discuss, by estimating the energy stored in the string, whether there is a significant risk to the guitar player when the string breaks.

___

___

___

___

___

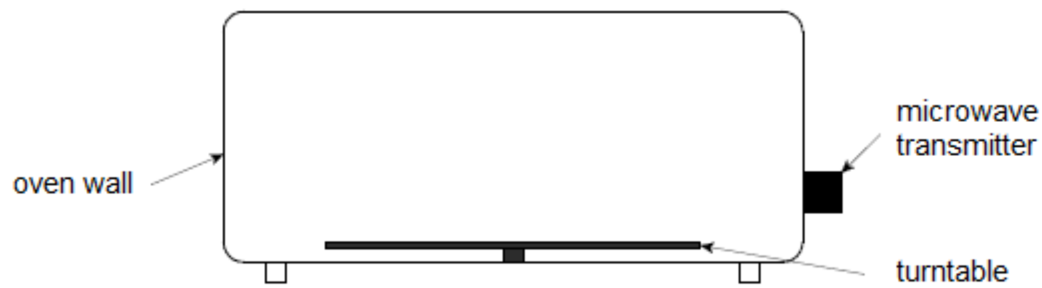
___

(3)

(Total 9 marks)

20 **Figure 1** is a diagram of a microwave oven.

Figure 1



A student wants to use the stationary waves formed in the microwave oven to measure the frequency of the microwaves emitted by the transmitter.

(a) Suggest how stationary waves are formed in the microwave oven.

___

___

___

___

___

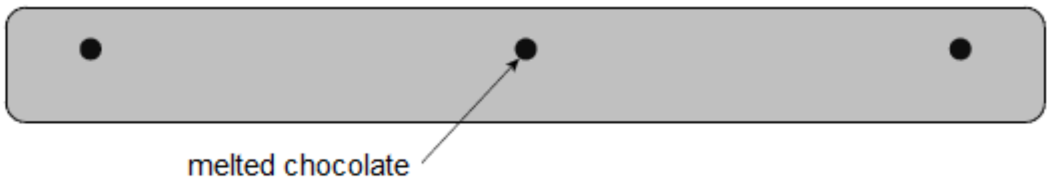
___

___

(2)

(b) The student removes the turntable and places a bar of chocolate on the floor of the oven. He then switches the oven on for about one minute. When the chocolate is removed the student observes that there are three small patches of melted chocolate with unmelted chocolate between them. **Figure 2** is a full-sized diagram of the chocolate bar.

Figure 2



Suggest why the chocolate only melts in the positions shown.

___

___

___

___

(2)

(c) Calculate, by making suitable measurements on **Figure 2**, the frequency of the microwaves used by the oven.

frequency = ____________________ Hz

(5)

(d) Explain why most microwave ovens contain a rotating turntable on which the food is placed during cooking.

___

___

___

(1)

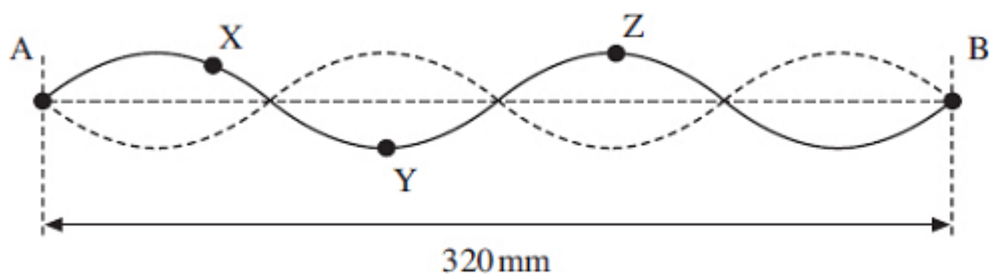
(Total 10 marks)

21

When a note is played on a violin, the sound it produces consists of the fundamental and many overtones.

Figure 1 shows the shape of the string for a stationary wave that corresponds to one of these overtones. The positions of maximum and zero displacement for one overtone are shown. Points **A** and **B** are fixed. Points **X**, **Y** and **Z** are points on the string.

Figure 1



(a) (i) Describe the motion of point **X**.

____

____

____

____

(2)

(ii) State the phase relationship between

X and **Y** ____

X and **Z** ____

(2)

(b) The frequency of this overtone is 780 Hz.

(i) Show that the speed of a progressive wave on this string is about 125 ms^{-1}.

(2)

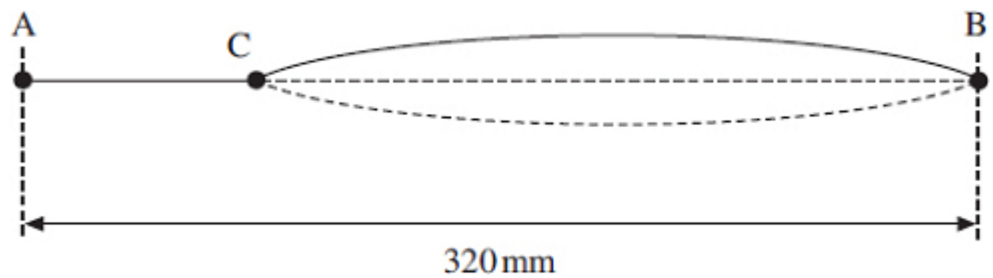
(ii) Calculate the time taken for the string at point **Z** to move from maximum displacement back to zero displacement.

answer = ______________________ s

(3)

(c) The violinist presses on the string at **C** to shorten the part of the string that vibrates. **Figure 2** shows the string between **C** and **B** vibrating in its fundamental mode. The length of the whole string is 320 mm and the distance between **C** and **B** is 240 mm.

Figure 2



(i) State the name given to the point on the wave midway between **C** and **B**.

____

(1)

(ii) Calculate the wavelength of this stationary wave.

answer = ____________________ m

(2)

(iii) Calculate the frequency of this fundamental mode. The speed of the progressive wave remains at 125 ms^{-1}.

answer = ____________________ Hz

(1)

(Total 13 marks)

22 The equation for the speed, v, of a transverse wave along a stretched string is:

$$v = \sqrt{\frac{T}{\mu}}$$

where T is the tension in the string and μ is the mass per unit length of the string.

(a) State the quantities that would need to be measured in order to calculate a single value for the speed of the wave using the equation. Name a suitable measuring instrument for each quantity.

____

____

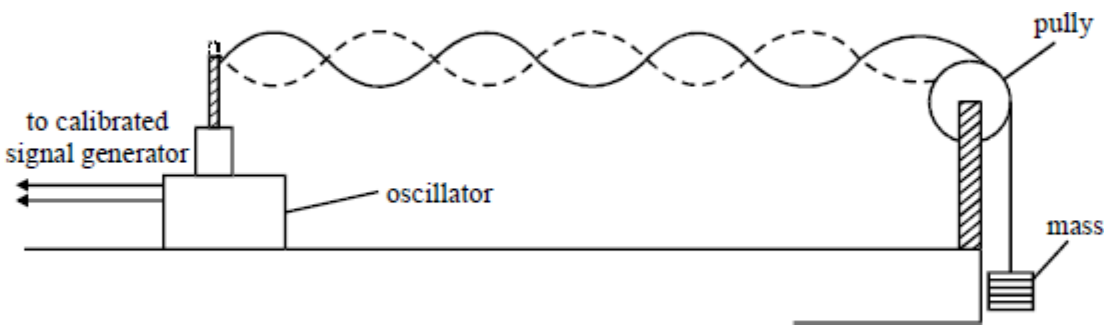
____

____

____

(4)

(b) The apparatus shown in the diagram below could be used to measure a value for v.



Explain how this apparatus may be used to calculate an accurate value of the speed of the transverse wave along the string.

____

____

____

____

____

____

(4)

(c) With the signal generator in the diagram below set at 152 Hz, 10 loops fit the vibrating length of the string exactly. The string is of length 2.0 m and the mass on the end of it is 0.72 kg.

the Earth's gravitation field strength, $g = 9.8 \text{ N kg}^{-1}$

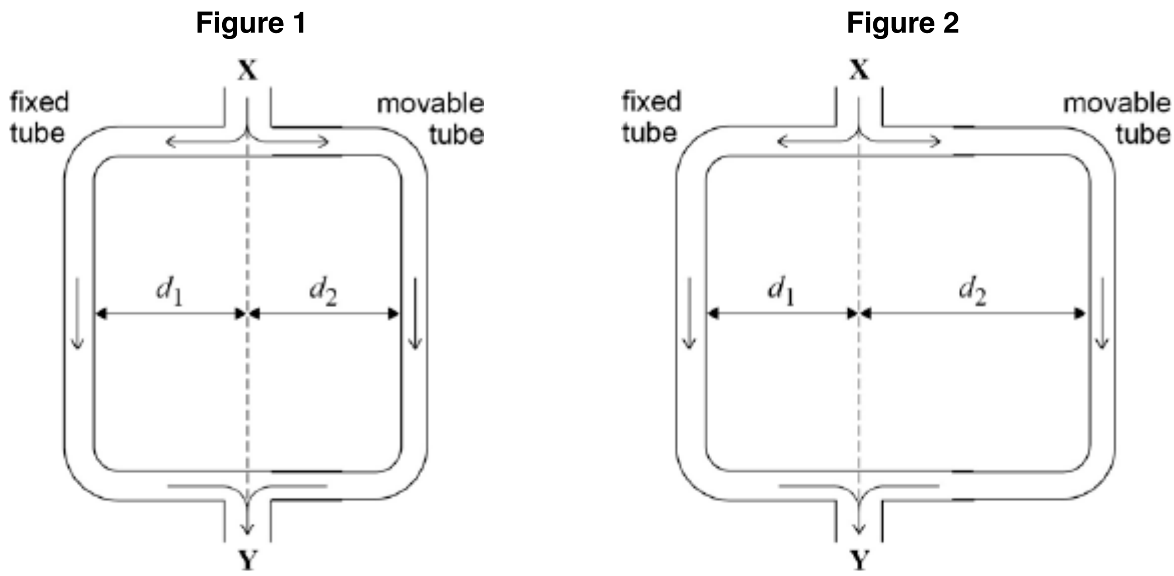
Calculate the mass of the string.

Mass = ____________________

(5)

(Total 13 marks)

23 **Figure 1** and **Figure 2** show a version of Quincke's tube, which is used to demonstrate interference of sound waves.



A loudspeaker at **X** produces sound waves of one frequency. The sound waves enter the tube and the sound energy is divided equally before travelling along the fixed and movable tubes. The two waves superpose and are detected by a microphone at **Y**.

(a) The movable tube is adjusted so that $d_1 = d_2$ and the waves travel the same distance from **X** to **Y**, as shown in **Figure 1**. As the movable tube is slowly pulled out as shown in **Figure 2**, the sound detected at **Y** gets quieter and then louder.

Explain the variation in the loudness of the sound at **Y** as the movable tube is slowly pulled out.

____

____

____

____

____

____

____

(4)

(b) The tube starts in the position shown in **Figure 1**.

Calculate the minimum distance moved by the movable tube for the sound detected at **Y** to be at its quietest.

frequency of sound from loud speaker = 800 Hz
speed of sound in air = 340 m s^{-1}

minimum distance moved = ____________________ m

(3)

(c) Quincke's tube can be used to determine the speed of sound.

State and explain the measurements you would make to obtain a value for the speed of sound using Quincke's tube and a sound source of known frequency.

____

____

____

____

____

____

____

____

____

(4)
(Total 11 marks)

24

(a) When an earthquake occurs longitudinal waves (P waves) and transverse waves (S waves) are produced in the Earth's crust. The P waves travel faster than the S waves. A station, whose task is to detect and locate the position of earthquakes, is at a distance d from the point where the earthquake originates (the epicentre).

The speed of P waves is 7.5 km s^{-1} and that of S waves is 5.0 km s^{-1} . For a particular earthquake the station detects the P wave 1.5 s before the S wave.

(i) Write down expressions for the time it takes each wave to travel the distance d from the epicentre to the station.

Time for P waves ____

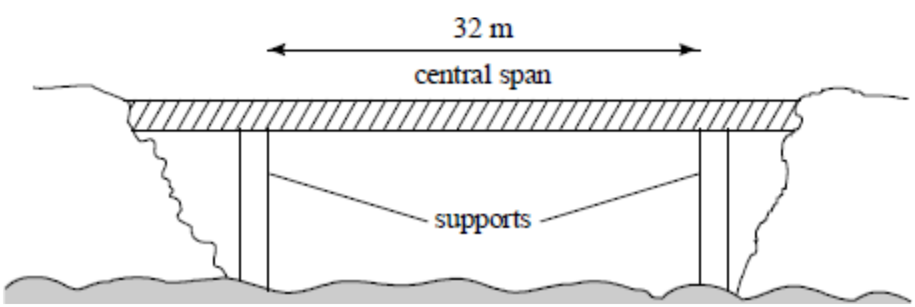
Time for S waves ____

(1)

(ii) Determine the distance of the epicentre from the station.

(2)

(b) The earthquake can set up resonant vibrations in bridges causing them to collapse. The diagram below shows one such bridge. The modes of vibration of the bridge are similar to those of a stretched string.



(i) Explain how a stationary wave is set up in a stretched string.

____

____

____

____

____

(2)

(ii) The velocity of transverse waves along the bridge is 180 m s^{-1}. Determine the frequency of the vibrations produced by an earthquake that would cause the central span of the bridge to resonate at its fundamental frequency (first harmonic).

(3)

(iii) A designer assumes the highest frequency produced by an earthquake is 1.5 times the fundamental frequency and decides to modify the bridge by building an extra support midway between the two existing supports.

Explain whether this modification would eliminate resonant vibrations caused by an earthquake.

___

___

___

___

___

___

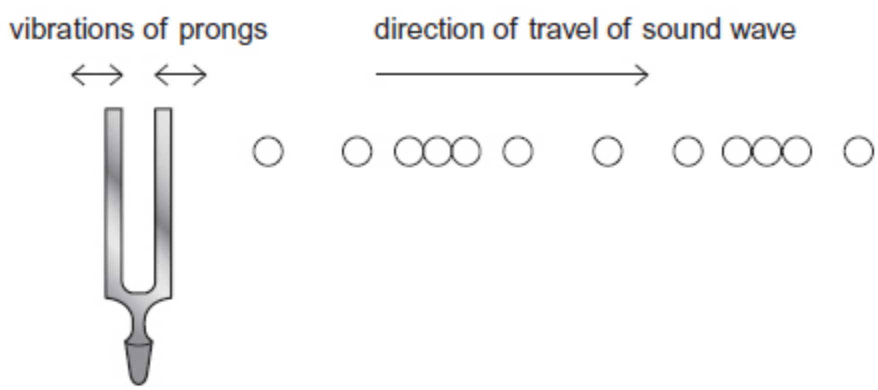
(2)

(Total 10 marks)

25 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.

Figure 1



(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}

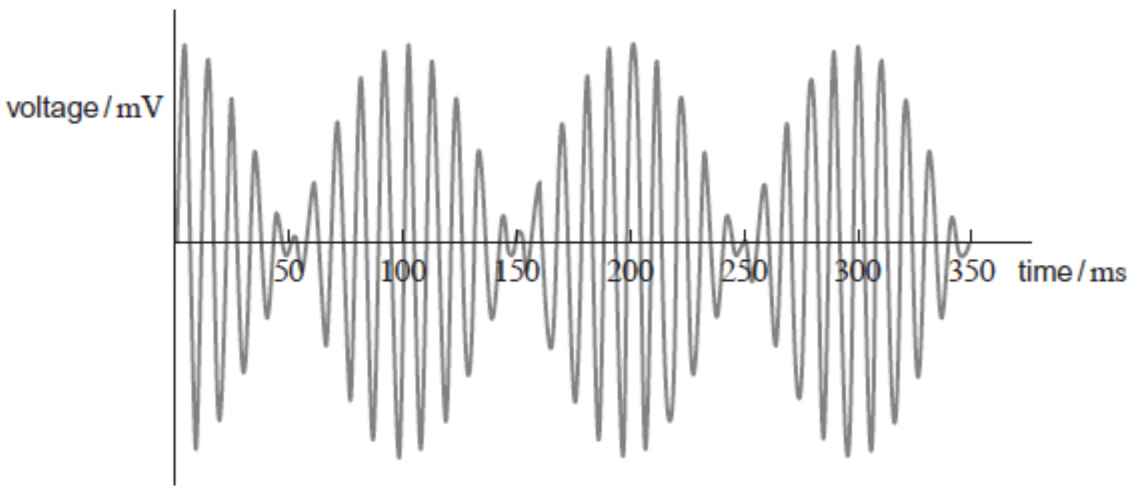
minimum separation ____________________ m

(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.

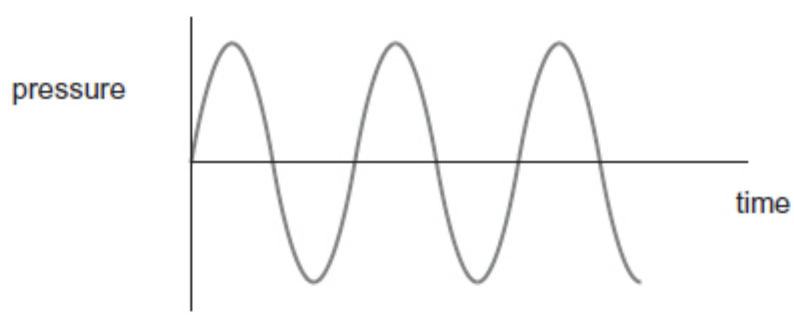
frequency ____________________ Hz

(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**.

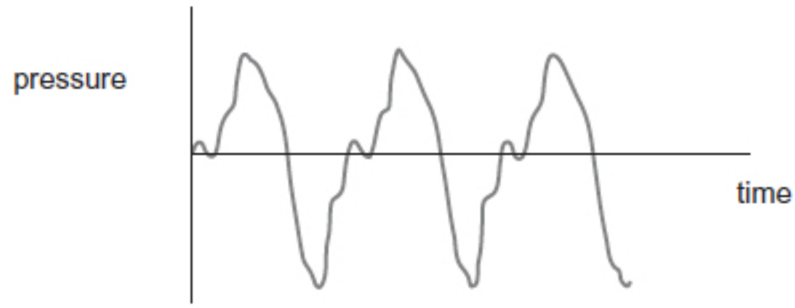
Figure 3



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.

Figure 4



(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)