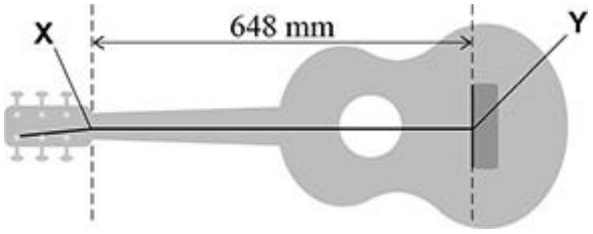
Q1.

Figure 1 shows a guitar with only one of its strings attached.
The string is fixed at **X** and **Y**.
The string is plucked and vibrates freely between **X** and **Y**.
The distance **XY** is 648 mm.

Figure 1



(a) The frequency of the first harmonic is 147 Hz.

Calculate the speed of the wave travelling in the string.

speed of wave = _____ m s^{-1}

(2)

(b) The tension in the string is 71 N.

Calculate the mass of the string between **X** and **Y**.

mass = _____ kg

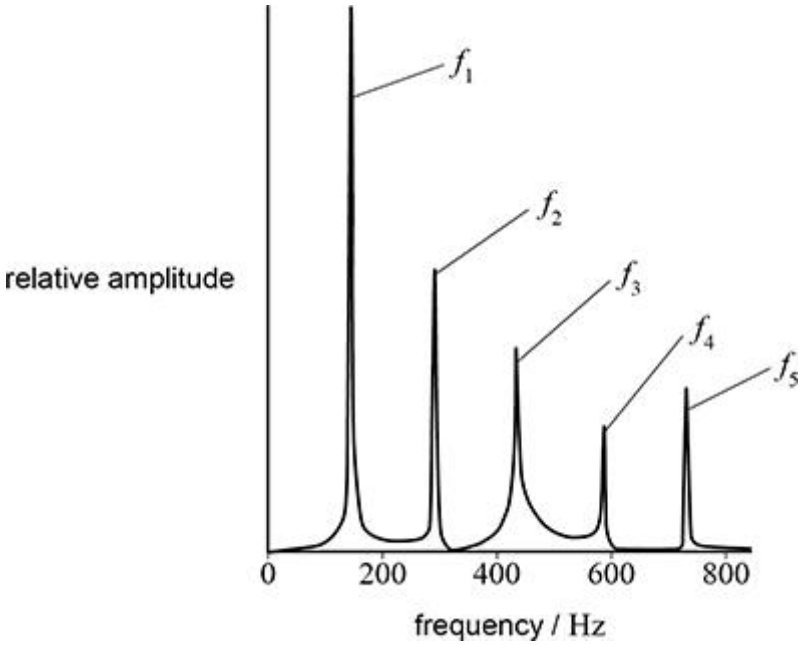
(3)

The sound produced by the guitar is analysed.

The sound is the superposition of the first harmonic f_1 with harmonics f_2, f_3, f_4 and f_5 of the stationary waves that exist on the string.

Figure 2 shows the frequencies of these harmonics and their relative amplitudes.

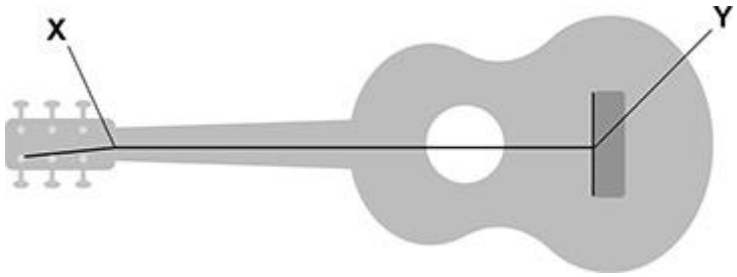
Figure 2



(c) Draw, on **Figure 3**, the stationary wave that produces the harmonic f_3.

Label the positions of all nodes **N** and all antinodes **A**.

Figure 3

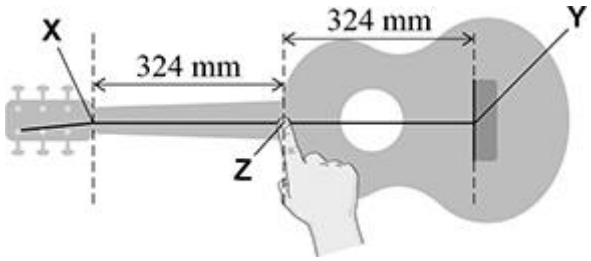


(3)

(d) The string is vibrating freely.
The player then touches the string lightly at its midpoint **Z** as shown in **Figure 4**. This prevents the string from vibrating at **Z**.

The sections **XZ** and **ZY** of the string continue to vibrate.

Figure 4



The sound produced by the guitar is analysed.

Deduce, with reference to frequency, how the harmonics present in this sound compare with the harmonics present in **Figure 2**.

(3)

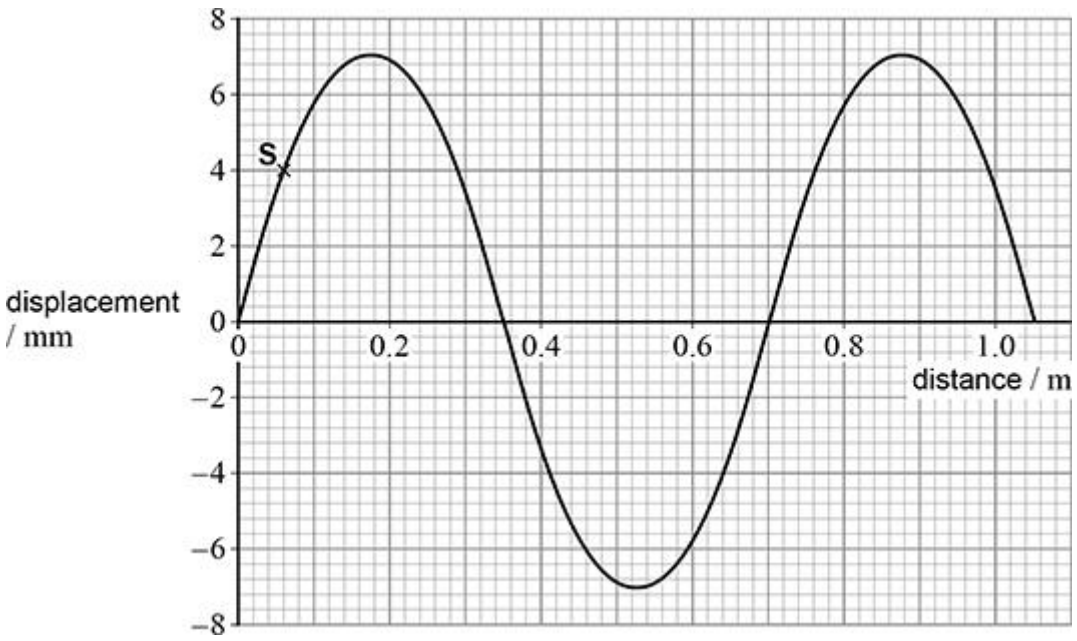
(Total 11 marks)

Q2.

An experiment is done to investigate stationary waves on a string.
A string of length 1.05 m is attached between a clamp stand and a vibration generator. A stationary wave is formed on the string when the vibration generator frequency is 625 Hz.

Figure 1 shows the variation of displacement with distance from one end of the string at time $t = 0$
At this time all points on the string have their maximum displacement.
S is one point on the string.

Figure 1



The stationary wave is produced by two progressive waves travelling in opposite directions on the string.

(a) Deduce the amplitude of one of the progressive waves.

amplitude = _____ mm

(1)

(b) Determine, in $\mathrm{m\ s^{-1}}$, the speed of one of the progressive waves.

speed = _____ $m\ s^{-1}$

(2)

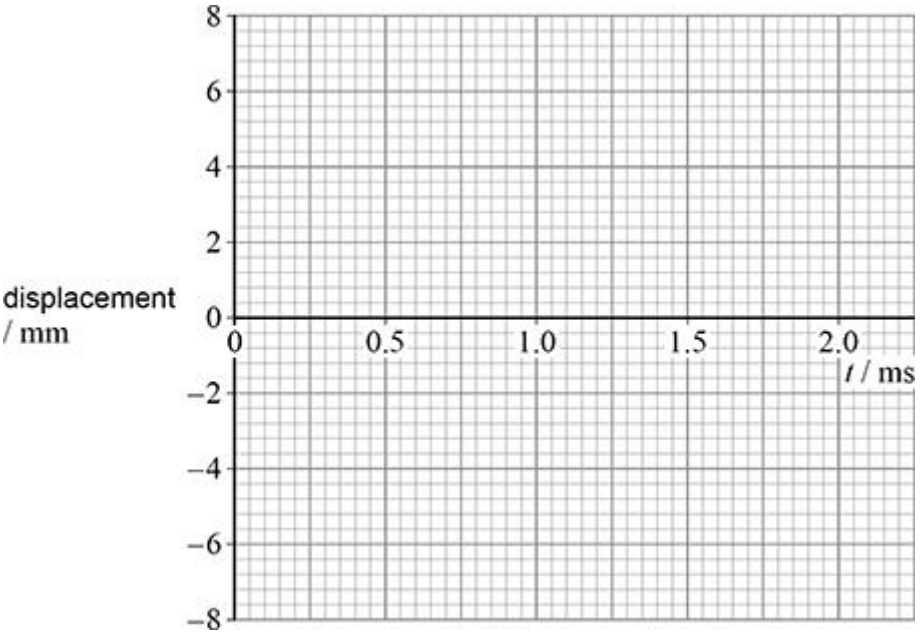
(c) State the phase relationship between the two waves when $t = 0$

_____

(1)

(d) Sketch, on **Figure 2**, a graph to show how the displacement of **S** varies with t.

Figure 2



(3)

(Total 7 marks)

Q3.

A student sits near a lake on a sunny day.

Some sunlight is reflected from the surface of the lake. Sunlight is also reflected from objects submerged beneath the surface of the lake. The light reflected from the surface makes it difficult to see the submerged objects.

Sunlight that reflects from the surface of the lake is horizontally polarised. Sunlight that reflects from the submerged objects is unpolarised.

The student puts on a pair of Polaroid sunglasses. The amount of light he sees reflected from the surface is significantly reduced.

Explain why the student can now see the submerged objects more clearly.

In your answer you should:

- describe the nature of an unpolarised wave
- explain what is meant by polarisation
- explain the relative effect of the Polaroid sunglasses on the light reflected from the surface and the light reflected from the submerged objects.

(Total 6 marks)

Q4.

A student buys a portable loudspeaker that is powered by its own internal battery. The battery in the loudspeaker is initially uncharged.

(a) The battery is connected to a charger that maintains a constant potential difference of $5.0\ \text{V}$ across the battery. It takes 2.6 hours for the battery to become fully charged. The average current in the battery during this time is $2.0\ \text{A}$.

The battery is disconnected from the charger.
The fully-charged battery operates the loudspeaker for 12 hours before it is completely discharged.

Calculate the average output power of the battery during these 12 hours.

average output power = _____ W

(2)

(b) A mobile phone transmits data to the loudspeaker using microwaves. The data are processed at the loudspeaker to produce sound waves.

Microwaves and sound waves travel at different speeds.

Describe **two** other differences between microwaves and sound waves.

1 _____

_____

2 _____

_____

(2)

(c) A second loudspeaker receives the same data from the mobile phone. The two loudspeakers act as coherent sources of sound waves.

State the **two** conditions required for the sources to be coherent.

1 _____

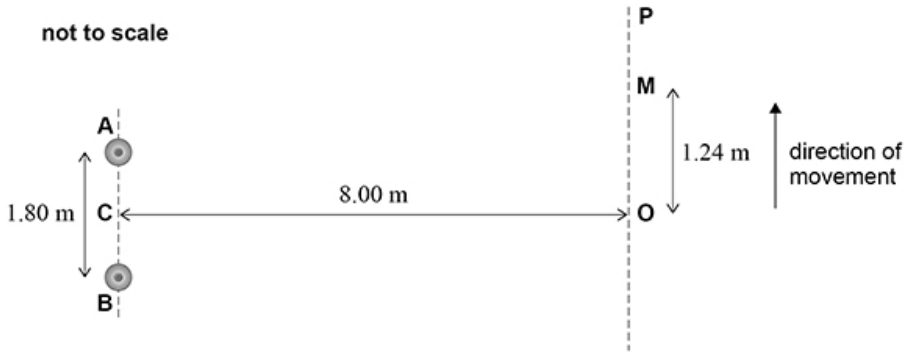
_____

2 _____

_____

(2)

The figure below shows two loudspeakers **A** and **B** that act as coherent point sources of sound of a single frequency.



C is the midpoint between **A** and **B**.
Distances **OA** and **OB** are equal.
OP is perpendicular to **CO**.

The student uses a sound-level meter to measure the intensity of the sound. The meter detects a maximum intensity at **O**.
The student moves the meter along **OP**. The intensity decreases and reaches a first minimum at **M**. The intensity then increases as the meter moves towards **P**.

The student records the following distances:

AB = 1.80 m
CO = 8.00 m
OM = 1.24 m.

(d) Show that the difference between the path lengths **AM** and **BM** is approximately 0.3 m.

(2)

(e) The speed of sound is $340\ \text{m s}^{-1}$.

Determine the frequency of the sound waves.

frequency = _____ Hz

(2)

(Total 10 marks)