lit 17

SECTION A

Answer **all** the questions.

1 This question is about notes produced by a flute.

A flute is an instrument that produces standing waves with displacement antinodes (A) at both ends. The nodes (N) and antinodes for the lowest note possible for a flute of length L are shown in Fig. 1.1.

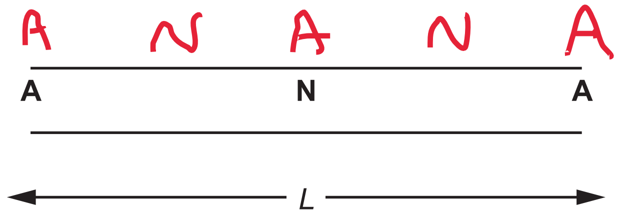


Fig. 1.1

(a) Explain how standing waves are formed in air.

- Waves reflect from end of tube
- Superpose as ~~they~~ pass through each other
- forming node where cancel & antinodes where positive superposition/interference

.... **[3]**

(b) Mark the antinodes and nodes on Fig. 1.2 for a note of **twice** the frequency of the note indicated in Fig. 1.1. Explain your answer.

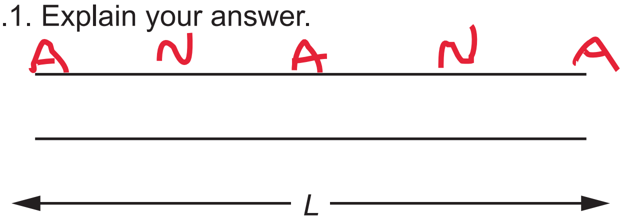


Fig. 1.2

$\frac{1}{2}\lambda \Rightarrow 2f$ (v same)

.... **[2]**

(c) The velocity of sound in air v is given by the equation $v = \sqrt{\frac{kp}{\rho}}$ ... 1 where p is the pressure of the gas, ρ is the density of the gas and k is a constant.

Use the expression $pV = nRT$ and the expression for density, $\rho = \frac{m}{V}$, to show that

$v = \sqrt{\frac{kRT}{M}}$ where $M = \frac{m}{n}$ is the mass of one mole of air.

$\rho = \frac{m}{V}$ $\quad V = \frac{m}{\rho}$ $\quad \therefore \frac{m}{\rho} = \frac{nRT}{p}$

$V = \frac{nRT}{p}$ $\quad \Rightarrow \frac{p}{\rho} = \frac{nRT}{m}$

Sub into ... 1 $\quad v = \sqrt{\frac{knRT}{m}}$ $\quad \frac{n}{m} = \frac{1}{M}$

$\therefore v = \sqrt{\frac{kRT}{M}}$ qed

[2]

(d) A flute of length L sounds a note of 262 Hz at a temperature of 293 K. Calculate the frequency of the note from the same length flute when the temperature of the air in the flute has increased to 303 K. The change in length of the flute caused by this temperature rise is negligible.

$c = f\lambda \Rightarrow f\lambda = \sqrt{\frac{kRT}{M}} \Rightarrow f \propto \sqrt{T}$

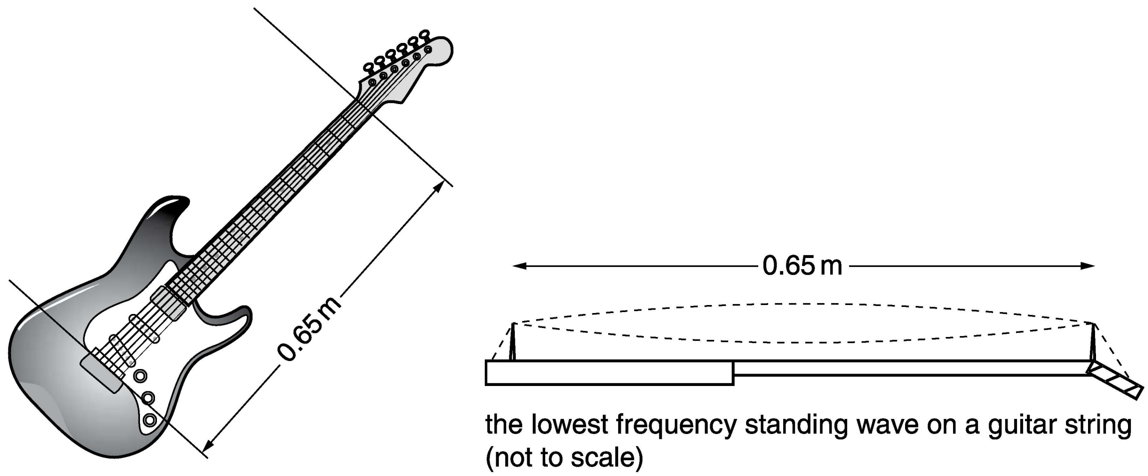
$\frac{f_1}{\sqrt{T_1}} = \frac{f_2}{\sqrt{T_2}} \Rightarrow \frac{262}{\sqrt{293}} \times \sqrt{303} = f_2$

frequency at 303 K = ...266........ Hz **[3]**

Section B

8 This question is about standing waves on guitar strings.

Fig. 8.1 shows a guitar whose strings are 0.65 m long.



the lowest frequency standing wave on a guitar string (not to scale)

Fig. 8.1

(a) Explain why the wavelength of the standing wave shown in Fig. 8.1 is 1.3 m.

We have $\frac{1}{2}$ a wave on a 0.65m string so $\lambda = 2 \times 0.65 = 1.3\text{m}$

[1]

(b) The lowest frequency standing wave on the thickest guitar string is at 82 Hz.
Show that the speed of the wave travelling along the string is about 100 m s^{-1}.

$\lambda = 1.3\text{m}$ $f = 82\text{Hz}$ $c = f\lambda = 106\text{ m/s}$

(106.6)

[2]

(c) (i) The speed *v* of waves along a string is given by the equation

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

where *T* is the tension in the string, and μ is the mass of a metre length of the string.

Use this equation to calculate the tension *T* in the thickest guitar string where $\mu = 8.4 \times 10^{-3}\,\mathrm{kg\,m^{-1}}$.

$v^2 = \frac{T}{\mu} \Rightarrow v^2 \times \mu = T = (106.6)^2 \times 8.4 \times 10^{-3}$

tension = 9.5 N **[2]**

(ii) All strings on the guitar have the same tension and length. Use the equation above to explain why the fundamental frequency of the thinnest string is higher than the fundamental frequency of the thickest string.

T/u will therefore go up. So V goes up too. freq = speed/wavelength therefore if speed up and wavelength same then freq up

[1]

(d) Explain clearly how waves travelling along a string can produce standing waves on the string.

In your answer, you should use appropriate technical terms, spelled correctly.

Waves of same freq are reflected from the fixed ends and can therefore interfere with each other as they travel up and down the string.

Where there is constructive inteference an antinode develops. Where the interference is destructive a node is created.

you get nodes at each end, and an antinode in the middle (for the longest wavelength)

[3]

[Total: 9]

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Section B

8 This question is about the interference of microwaves.
Two students set up the apparatus shown in Fig. 8.1.

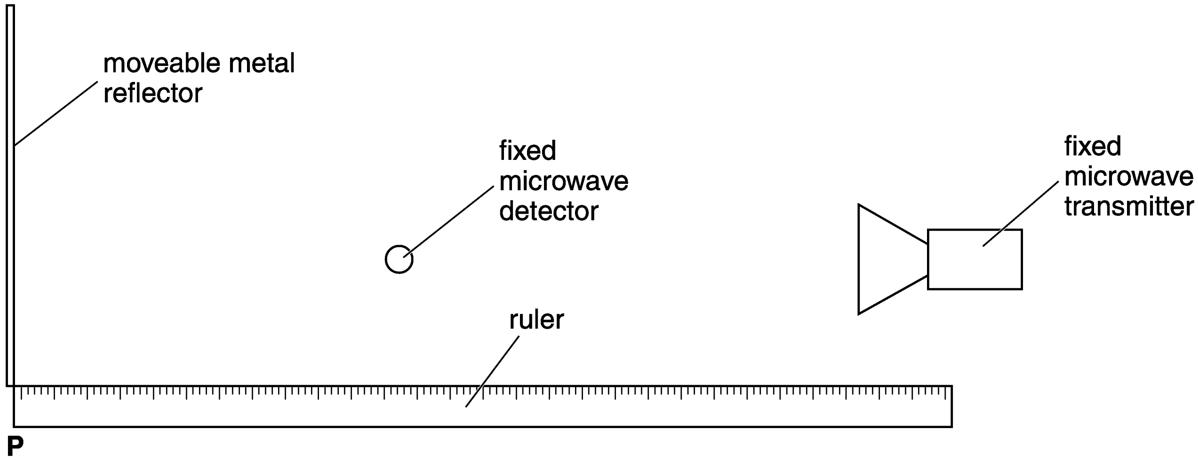

Fig. 8.1

(a) It is observed that when a metal reflector is placed at point **P**, the signal received by the detector falls.
Explain why this happens.

waves from the transmitter are interfering with waves reflected from the reflector.

At P enough path difference is introduced for the waves interfering at the detector to be out of phase and so the signal drops.

[2]

(b) The reflector is moved slowly towards the microwave detector. The graph of Fig. 8.2 shows how the signal strength at the detector varies for different positions of the reflector.

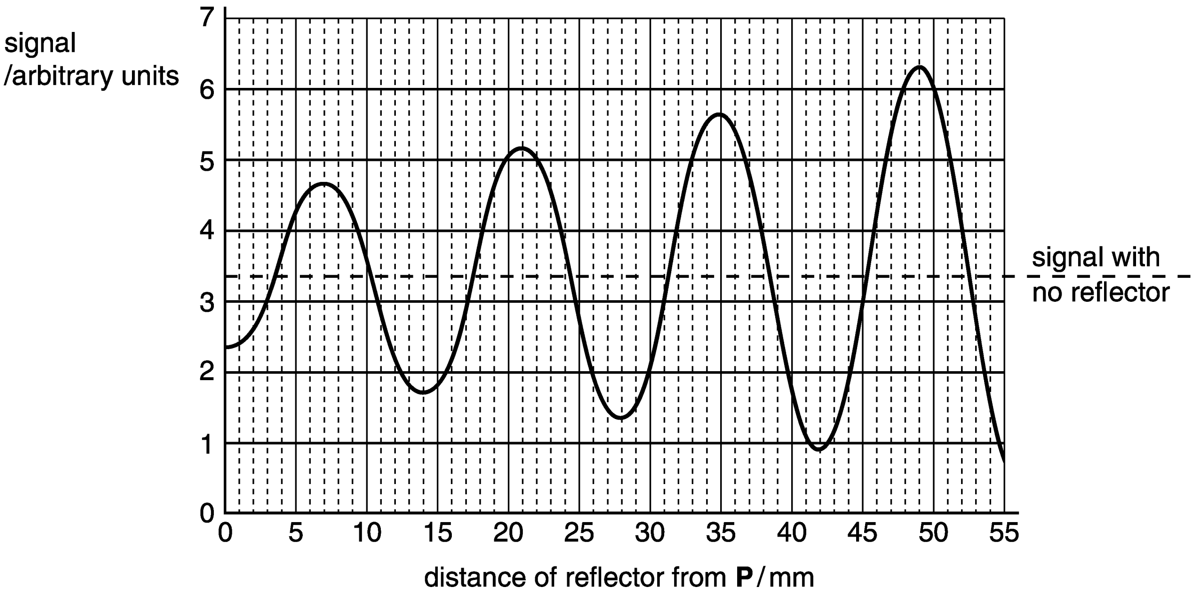

Fig. 8.2

The line of dashes shows the strength of the signal **before** the metal reflector is put at point **P**.

(i) Explain why the signal varies between maxima and minima as the reflector is moved towards the detector.

the pd between transmitted and reflected waves is changing. At the peaks it is a whole number of wavelenghts and so we get constructive intereference. At the minima the phase difference is nXwavelegnth/2

[2]

(ii) Use information from Fig. 8.2 to calculate the wavelength of the microwaves.
Make your working clear.

peak to peak is 14mm - the distance of half a wavlength so 28mm

wavelength = ... mm **[2]**

(c) The experiment is now repeated with the transmitter closer to the detector. The detector remains fixed in the same place, and the reflector is again moved slowly towards it, starting at **P** as before.
Explain one feature of the results in Fig. 8.2 that would remain the same, and one feature that would change.

In your answer you should use appropriate technical terms spelled correctly.

since lambda is unchanged the graph will have the same distance between peaks/

Since the detector is closer the intensity of the signal (both transmitted and reflected) will be greater and therefore the peaks will be higher

[4]

[Total: 10]