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Standing waves (2) — A Physics

- V sound in air = 330 m/s
- Vibrating string / wire.

$$f_0 = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

T – N, μ – kg/m, l – m

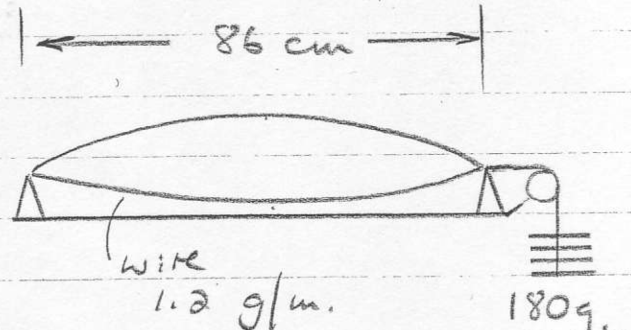
1. <u>Vibrating wires</u>

The diagram shows a vibrating wire. What is...

(a) the frequency? (4)

(b) the wavelength of the waves in the wire (2)

(c) the velocity of the progressive waves in the wire? (2)



(d) Draw a labelled diagram to show the 1st harmonic vibration. What is the frequency and velocity of the waves now? (4)

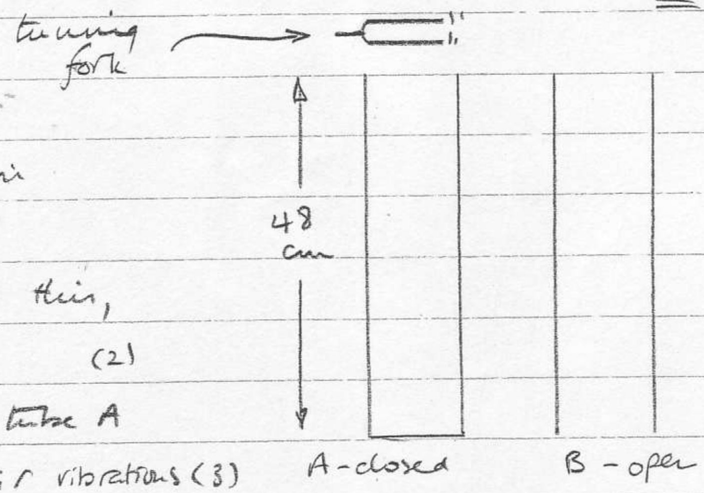
Refer to the diagram and part (a) for the rest of the question. What will the new fundamental frequency be if...

(e) the mass is doubled – keeping length the same (2)

(f) the length is doubled – keeping mass the same (2)

(g) What new mass is needed to produce a fundamental frequency of 60 Hz? (3) [19]

2. <u>Sound in pipes</u>



A student gets resonance in tube A.

(a) Explain how he would know this, and what is happening. (2)

(b) Draw a labelled diagram of tube A – showing size and direction of air vibrations (3)

(c) Calculate wavelength and frequency of the standing wave (3)

(d) The student finds he can get resonance occurring in tube A at a higher frequency. Explain this, draw a diagram to show the new wave, and calculate the frequency (4)

(e) The student cuts the end of the tube A, so it becomes tube B. and finds a new fundamental resonant frequency. Draw the diagram, and calculate wavelength and frequency. (4) [16]

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Standing waves (2) — Answers

A Physics

1. (a) $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}} = \frac{1}{2 \times 0.86 \text{ (1) (m)}} \sqrt{\frac{0.18 \times 10 \text{ (1) (kg)}}{1.2 \times 10^{-3} \text{ (1) (kg/m)}}} = 22.5$ (1) Hz. (4)

(b) for fundamental . . . . $\lambda = 2l$ (1) $= 1.72$ (1) m (2)

(c) $v = f\lambda$ (1) $= 22.5 \times 1.72 = 38.7$ (1) m/s (2)

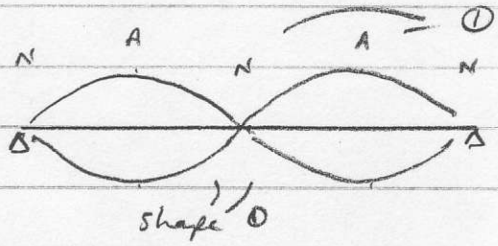
(d) 1st harmonic . . .

$f_1 = 2 \times f_0 = 45.0$ Hz (1)

v wave is the same as before ! $= 38.7$ m/s (1)

$v = f\lambda$ — f doubled — λ halved.

total (4)



(e) referring to (a) . . .

double mass T_{new} is $2 \times T_{old}$ so $\sqrt{T_{new}} = \sqrt{2} \times \sqrt{T_{old}}$

so $f_{new} = 1.4 \times f_{old} = 1.4 \times 22.5 = 31.8$ Hz

(f) double length $l_{new} = 2 \times l_{old}$ so $f_{new} = \frac{1}{2} f_{old} = 11.3$ Hz.

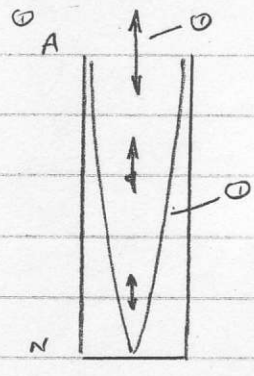
$\boxed{19}$

(g) rearranging... $f_0^2 = \frac{1}{4l^2}\frac{T}{\mu} \rightarrow T = f_0^2 4l^2\mu$ (1)

so tension needed is . . . . 12.8 (1) N $\rightarrow$ mass needed is 1.3 (1) kg.

2. (a) sound is louder (1), because of standing wave (1) . . . column of air vibrates at its natural frequency (2)

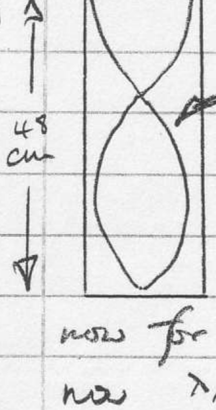
(b) see diagram . . . $\rightarrow$ (3)



(c) tube length $l = \lambda/4 \rightarrow \lambda = 4 \times .48 = 1.92$ (1) m

$v_{sound} = f\lambda$ (1) $\rightarrow f_{sound} = v/\lambda = 330/1.92 = 172$ (1) Hz (3)

(d)



new standing wave is the 1st harmonic (1)

diagram (1)

λ of 1st harmonic $= \frac{1}{3}\lambda$ fundamental (1)

so $f_1 = 3 \times f_0 = 516$ (1) Hz (4)

or... $\frac{3\lambda}{4} = 0.48$ m

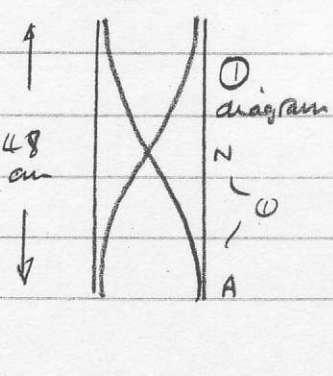
$\lambda = 0.64$ m

so $f = v/\lambda = 516$ Hz

(e) now for tube B . . .

now $\lambda/2 = 48$ cm $\rightarrow \lambda = 0.96$ m (1)

so new $f_0 = v/\lambda = 330/0.96 = 344$ (1) Hz $\boxed{16}$



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