1 The fundamental frequency f is the lowest frequency heard when a stretched string is vibrating.

The string is now lightly touched one third of the way along its length.

What is the lowest frequency heard?

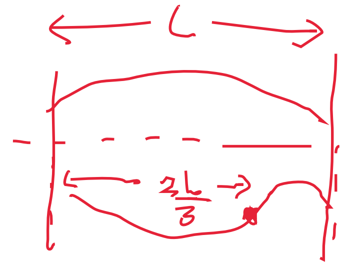
A $\frac{f}{3}$

B $\frac{2f}{3}$

C f

D $3f$

$c = f\lambda$



$c = f_1 2L$

$c = f_2 \frac{2L}{3}$

C is fixed

$\therefore f_1 2L = f_2 \frac{2L}{3}$

$3f_1 = f_2$

(Total 1 mark)

2 Two points on a progressive wave have a phase difference of $\frac{\pi}{6}$ rad

The speed of the wave is 340 m s^{-1}

What is the frequency of the wave when the minimum distance between the two points is 0.12 m?

A 240 Hz

B 470 Hz

C 1400 Hz

D 2800 Hz

$\frac{\pi}{6} \equiv 0.12\,m$

$\therefore$ a complete cycle (2π)

$= 12 \times 0.12 = 1.44\,m$

$c = f\lambda \Rightarrow f = \frac{c}{\lambda}$

$= 340/1.44$

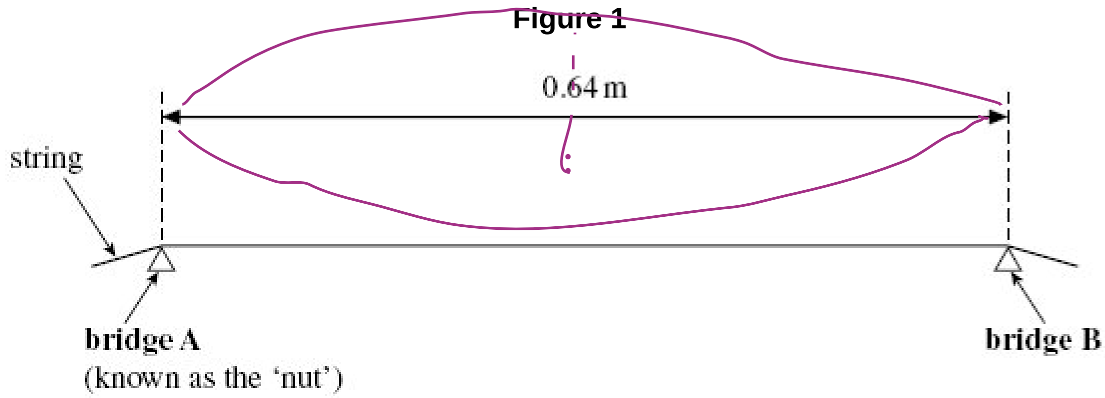
$= 236$ Hz

(Total 1 mark)

3 **Figure 1** shows a side view of a string on a guitar. The string cannot move at either of the two bridges when it is vibrating. When vibrating in its fundamental mode the frequency of the sound produced is 108 Hz.

(a) (i) On **Figure 1**, sketch the stationary wave produced when the string is vibrating in its fundamental mode.

Figure 1



(1)

(ii) Calculate the wavelength of the fundamental mode of vibration.

$\lambda = 2 \times 0.64$

answer = 1.28 m

1.3 (2 sf)

(2)

(iii) Calculate the speed of a progressive wave on this string.

$c = f\lambda = 108 \times 1.28$

answer = 138 m s^{-1}

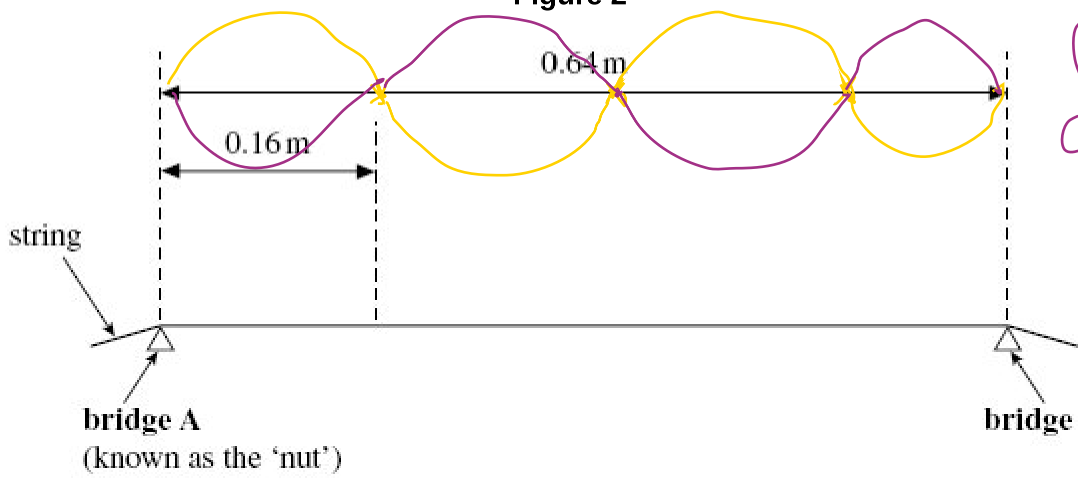
(2)

(b) While tuning the guitar, the guitarist produces an overtone that has a node 0.16 m from **bridge A**.

(i) On **Figure 2**, sketch the stationary wave produced and label all nodes that are present.

needs to be a carefully sketch

Figure 2



(2)

(ii) Calculate the frequency of the overtone.

$\lambda = \frac{0.64}{2}$ $f = \frac{c}{\lambda} = \frac{138}{0.64} \times 2$

answer = 431 Hz 430 (2 s.f.)

(1)

(c) The guitarist needs to raise the fundamental frequency of vibration of this string. State **one** way in which this can be achieved.

tighten it (decrease length)

Kinda hard to do but allowed

(1)

(Total 9 marks)

4 Which statement is **not** correct for ultrasound and X-rays?

A Both can be refracted ☐

B Both can be diffracted ☐

C Both can be polarised ☐

D Both can be reflected ☐

(Total 1 mark)

6 **Figure 1** shows the structure of a violin and **Figure 2** shows a close-up image of the tuning pegs.

Figure 1

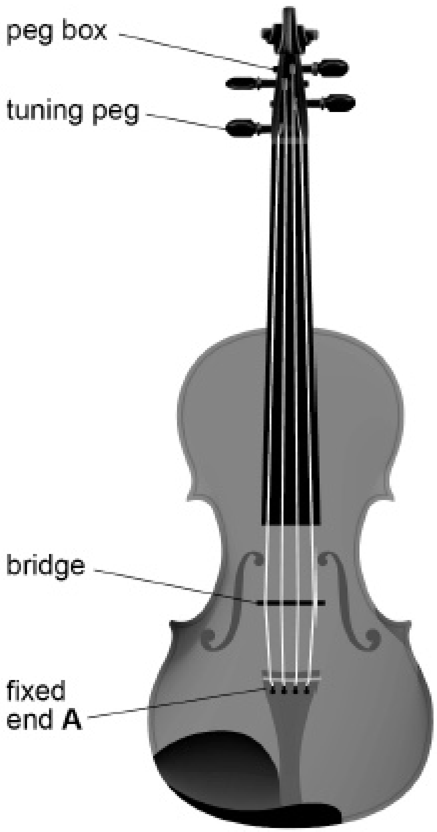
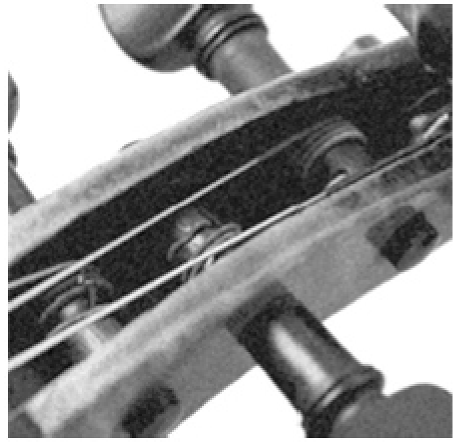


Figure 2



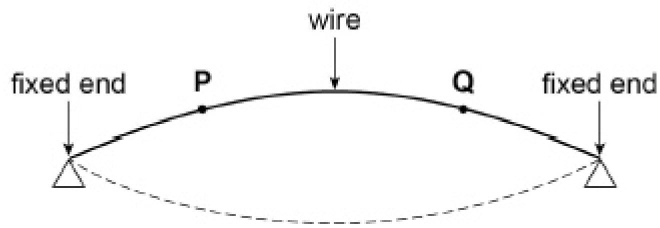
The strings are fixed at end **A**. The strings pass over a bridge and the other ends of the strings are wound around tuning pegs that have a circular cross-section. The tension in the strings can be increased or decreased by rotating the tuning pegs.

(a) Explain how a stationary wave is produced when a stretched string is plucked.

progressive waves travel along the string
reflect of the fixed ends
these interfere/superpose with each other creating nodes and antinodes (with a node at each end)

(3)

7 A uniform wire, fixed at both ends, is plucked in the middle so that it vibrates at the first harmonic as shown.



What is the phase difference between the oscillations of the particles at **P** and **Q**?

A zero

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

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

D $\frac{3\pi}{4}$ rad

clever question! Imagine watching P and Q - how do they move relative to each other?

(Total 1 mark)

1 **D**

[1]

2 **A**

[1]

3 (a) (i) one 'loop' (accept single line only, accept single dashed line)

+ nodes at each bridge (± length of arrowhead)

+ antinode at centre **(1)**

1

(ii) $\lambda_0 = 2L$ or $\lambda = 0.64 \times 2$ **(1)**

= 1.3 (m) **(1)** (1.28)

2

(iii) ($c = f\lambda$) = 108 × (a)(ii) **(1)**

= 138 to 140(.4) (m s^{-1}) **(1)** ecf from (a) (ii)

2

(b) (i) four antinodes **(1)** (single or double line)

first node on 0.16 m (within width of arrowhead)

+ middle node between the decimal point and the centre of the 'm' in '0.64 m'

+ middle 3 nodes labelled 'N', 'n' or 'node' **(1)**

2

(ii) ($4f_0$ =) 430 (Hz) **(1)** (432)

or use of $f = \frac{v}{\lambda}$ gives 430 to 440 Hz correct answer only, no ecf

1

(c) decrease the length/increase tension/tighten string **(1)**

1

[9]

4 **C**

[1]

5 **C**

[1]

6 (a) Waves travel to the boundaries and are reflected ✓

Not bounce off ...

1

two waves travelling in opposite directions interfere/superpose ✓

Not superimpose or interferes with itself

1

Fixed boundaries (cannot move so) are nodes ✓

creates nodes and antinodes bland = 0

In some positions the waves always cancel /interfere destructively to give zero amplitude/no vibration/nodes)

OR

interfere constructively to produce positions of maximum amplitude/maximum vibration/antinodes ✓

1

Max 3

(b) Use of $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ ✓

Either rearranges for μ without substitution or substitutes correctly in the formula

1

4.2 (4.19) × 10^{-4} (kg) ✓

1

(c) 240 (244) (m s^{-1})

1

(d) 1 rotation of the peg = 22 mm ✓

Or Reads increase in tension produced by the extra extension (about 10 N) from graph and adds to 25

1

extra extension = 22 × 75/360 = 4.6 mm

(ecf for incorrect circumference) ✓

πd × 75/360 not evaluated =1

1

Total extension = 11 + 4.6 (15.6 mm) so tension 35 - 36N ✓

Inspect their length and their tension in the substitution

1

Calculates frequency **for their tension**

T must <u>be greater than</u> the original 25N

Condone adding or subtracting <u>extra</u> extension to 0.33 m

If 4.0×10^{-4} kg used then answer will be in range 448 Hz to 455 Hz

If 4.19×10^{-4} used 438 to 444 Hz

1

[10]

7 **A**

[1]