

Standing waves on strings and in pipes

Physics grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Model answers with a marking guide. Award method marks for correct use of the node and antinode conditions even when the final value is wrong, and check each answer carries the right unit.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB C.4

Question 1 Violin string (3 marks)

- a. $\lambda = 2L = \mathbf{1.8\ m}$.
- b. $f_1 = v/2L = 180 \div 1.8 = \mathbf{100\ Hz}$.
- c. $3f_1 = \mathbf{300\ Hz}$, with **3 antinodes**.

Marking: 1 mark for each part.

Question 2 Closed pipe resonances (3 marks)

- a. $f_1 = v/4L = 343 \div 1.60 = \mathbf{214.4\ Hz}$.
- b. $3f_1 = \mathbf{643.1\ Hz}$ and $5f_1 = \mathbf{1072\ Hz}$.

Marking: (a) 1; (b) 1 for each frequency.

Question 3 Reading the loops (3 marks)

- a. The **4th harmonic** (4 loops).
- b. $4 \times \lambda/2 = 1.20\ \text{m}$, so $\lambda = \mathbf{0.60\ m}$.
- c. $v = f\lambda = 200 \times 0.60 = \mathbf{120\ m/s}$.

Marking: 1 mark for each part.

Question 4 Two kinds of wave (3 marks)

(1) Energy is transferred along a progressive wave but not along a stationary wave. (2) All points on a progressive wave have the same amplitude; a stationary wave has nodes of zero amplitude and antinodes of maximum amplitude. (3) Phase changes steadily along a progressive wave, but points between adjacent nodes oscillate in phase and neighbouring loops are in antiphase. **One mark for each valid difference.**

Marking: 1 mark for each of three correct differences.

Question 5 Odd harmonics (2 marks)

The closed end must be a node and the open end an antinode. A length of $L = (2n - 1)\lambda/4$ with $n = 1, 2, 3...$ fits these conditions, so only f_1 , $3f_1$ and $5f_1$ can occur. **Even multiples would put a node at both ends or an antinode at both ends.**

Marking: 1 for node/antinode at the ends; 1 for odd quarter wavelengths.

Question 6 Doubling the tension (2 marks)

$f \propto \sqrt{T}$, so $f = 220 \times \sqrt{2} = \mathbf{311 \text{ Hz}}$.

Marking: 1 for $f \propto \sqrt{T}$; 1 for the answer.

Question 7 Fretting a string (2 marks)

For constant v , $f \propto 1/L$. $f = 110 \times 0.64 \div 0.48 = \mathbf{147 \text{ Hz}}$.

Marking: 1 for $f \propto 1/L$; 1 for the answer.

Question 8 End correction idea (2 marks)

The antinode at an open end forms slightly outside the pipe (about $0.6r$), so the effective length is longer than the physical length. If this is ignored, the length used is too small, so the calculated frequency is **too high**.

Marking: 1 for antinode beyond the end; 1 for frequency too high.