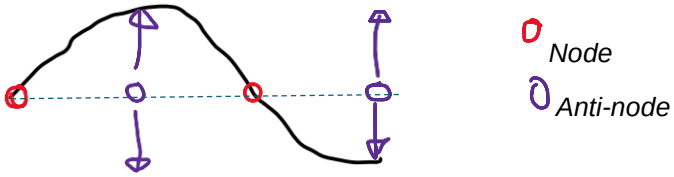
# Standing Waves Questions for A-level Physics (ANSWERS)

## Basic Concepts

**1.** What is the phase difference between particles at adjacent nodes in a standing wave?

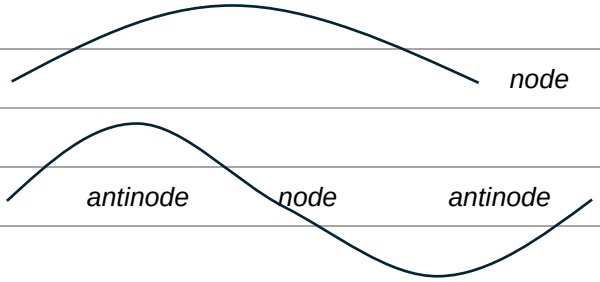
*The phase difference is π radians (or 180°). They are in anti-phase.*

**2.** Sketch a standing wave with two nodes and two antinodes. Label each part.




**3.** A string is 1.2 m long and has nodes at both ends. How many nodes and antinodes are present in the second harmonic?

*1st harmonic* *node* *node*



*2nd harmonic* *node* *antinode* *node* *antinode* *node*

∴ ***3 nodes and 2 antinodes***

**4.** Explain why there is no energy transfer in a standing wave, despite the wave being composed of oscillating particles.

*The energy is contained in between the nodes so there is no net energy transfer along the wave (as there is in a travelling wave).*

**5.** Describe the difference between pipe closed at both ends and a pipe open at one end, in terms of standing wave formation.

*A closed pipe has a node at each of the closed ends.*

*An open pipe has an antinode at the open end and a node at the closed end.*

## Calculation Questions

**6.** If a string vibrates in its fundamental mode at a frequency of 200 Hz and its length is halved, what is the new fundamental frequency?

*Length is halved and ∴ the wavelength of the standing wave is halved. The frequency is therefore doubled.*

*2 x 200 = 400Hz*

**7.** Given a string with mass per unit length μ=0.020 kg/m and tension T=50 N, calculate the frequency of the fundamental mode for a string of length L=1.0 m.

$f_1 = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$

$= \frac{1}{2 \times 1}\sqrt{\frac{50}{0.02}}$

$= ½ \times \sqrt{2500}$ = **25Hz**

**8.** If the tension in a string is quadrupled, by what factor does the fundamental frequency of the standing wave increase?

$f_1 \propto \sqrt{T}$

*∴ if tension is increased by 4x then frequency is increased by* $\sqrt{4}$ *i.e.* ***it is doubled***

**9.** A 1.0 m string has a fundamental frequency of 100 Hz. If its mass per unit length is 0.010 kg/m, calculate the tension in the string.

$f_1 = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ $200^2 = T / 0.01$

$2Lf_1 = \sqrt{\frac{T}{\mu}}$ T = **400N**

$2 \times 100 = \sqrt{\frac{T}{0.01}}$

**10.** A 0.75 m pipe closed at one end resonates at 115 Hz in its fundamental mode. Calculate the wavelength and the speed of sound.

*The length of the pipe is ¼ wavelength of the fundamental.*

*4 x 0.75 = 3 metres*

$V = f\lambda$ *= 115 x 3* = ***345ms$^{-1}$***

**11.** Calculate the tension needed in a 1.5 m string with a mass per unit length of 0.030 kg/m to produce a fundamental frequency of 120 Hz..

| | |
|---|---|
| $f_1 = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ | |
| $120 = \frac{1}{2 \times 1.5}\sqrt{\frac{T}{0.03}}$ | |
| $(120 \times 3)^2 = T / 0.03$ | T = **$3.9 \times 10^3$N** |

**12.** If a 2.0 m long string has a mass per unit length of μ=0.035kg/m and a fundamental frequency of 60 Hz, calculate the tension in the string.

| | |
|---|---|
| $f_1 = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ | |
| $60 = \frac{1}{2 \times 2}\sqrt{\frac{T}{0.035}}$ | |
| $(60 \times 40)^2 = T / 0.035$ | T = **$2.0 \times 10^3$N** |

**13.** A string with a length of 1.5 m has a fundamental frequency of 90 Hz when stretched with a tension of 30 N. Find the mass of the string.

| | |
|---|---|
| $f_1 = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ | $\mu = 30 / 270^2$ |
| $90 = \frac{1}{2 \times 1.5}\sqrt{\frac{30}{\mu}}$ | $= 0.000412$ kgm$^{-1}$ |
| $(90 \times 3)^2 = 30 / \mu$ | $m = \mu L = 0.000412 \times 1.5 =$ **$6.2 \times 10^{-4}$kg** |

**14.** Calculate the length of a string with a fundamental frequency of 75 Hz, a tension of 50 N, and a mass per unit length of μ=0.010 kg/m.

| | |
|---|---|
| $f_1 = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ | |
| $75 = \frac{1}{2L}\sqrt{\frac{50}{0.01}}$ | L = 0.943 /2 |
| $2L = \sqrt{5000}$ / 75 | = **0.47m** |

**15.** A 100 Hz standing wave is observed on a string under 30 N tension with mass per unit length μ=0.0050 kg/m. Determine the length of the string.?

| | |
|---|---|
| $f_1 = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ | |
| $100 = \frac{1}{2L}\sqrt{\frac{30}{0.005}}$ | |
| $L = \frac{1}{200}\sqrt{\frac{30}{0.005}}$ | = **0.39m** |