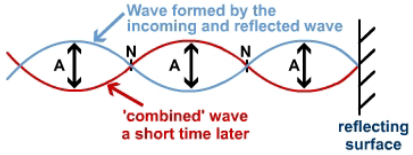
Standing Waves

Definitions

Reflection and superposition can give rise to standing waves.

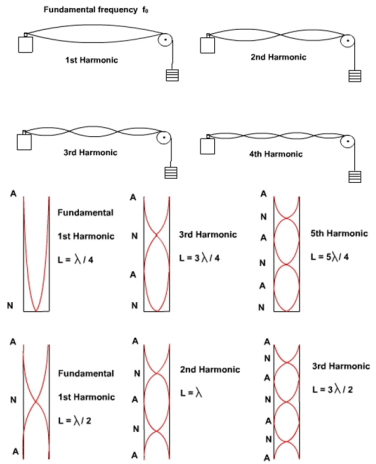
Strings fixed at each end are plucked in the middle; waves travel to each end and are reflected. The reflections cross and interfere to produce a standing wave with a frequency which is a natural or resonant frequency of the string. When a wave reflects, it comes back inverted (for example a crest becomes a trough). The reflected wave and the incoming wave interfere. At the reflecting surface the two waves are always exactly equal and opposite - so they always cancel out. Such a place is called a **node(N)**. At other points along the waves, the two ways always are the same - so they add together or interfere constructively and make a double size wave. Such points are called **antinodes(A)**.



The distance between two **NODES** or between two **ANTINODES** is half a wavelength, λ /2 of **one** of the waves**.**

Equations/Diagrams

$v = f\lambda$	Velocity of wave	v	m s^{-1}
	frequency	f	Hz
	wavelength	λ	m



Questions

QUESTION TWO (2019;2)

The speed of sound in air is 338 m s^{-1}.

Sam is experimenting with a 0.446 m length plastic pipe that is open at both ends. When the wind blows across the top of the pipe, Sam hears a sound. She assumes the sound is made by air inside the pipe resonating at the fundamental frequency.

(a) Show that the frequency of the sound is 379 Hz.

(b) Sam places her hand over the end of the pipe, and the frequency of the sound coming out of the pipe changes. Describe and explain the changes in the frequency of the pipe. Draw diagrams to support your answer.

(c) Sam removes her hand, so the pipe is open at both ends again. A strong gust of wind blows across the top of the pipe and causes a much higher pitched sound to be produced. Sam uses an app on her phone to determine that the frequency of the sound is 1138 Hz.
Draw the new standing wave formed in the pipe in the diagram.
Identify the harmonic that is resonating in the air column.

Terms

Antinode: A point of maximum amplitude because of constructive interference of waves

Closed Pipe: A pipe with one end open and the other end blocked up. A sock is a closed pipe – it is still open at one end so you can get your foot in.

Fundamental: This is the simplest standing wave the medium can produce. It is the lowest possible frequency.

Harmonic: An exact multiple of the fundamental frequency e.g., the second harmonic has twice the fundamental frequency

Node: A point in a stationary wave without any disturbances. Destructive interference occurs at nodes.

Open Pipe: A pipe with both ends open.

Phase change: When wave collides with an interface, the reflected wave has same speed/amplitude as incident wave but is upside down.

Standing waves: Where two waves of equal frequency traveling in opposite directions meet, they can produce these.

Tips

- Harmonics are multiples of fundamental (1st harmonic) e.g., if the 1st harmonic is 500 Hz, then the 7th harmonic is 7 x 500 = 3500 Hz
- Drawing a **labelled** diagrams includes the **labels** – focus less on the quality of your sine wave drawing and more on the A's and the N's

Answers

(a) $v = 338 \text{ m s}^{-1}$

$L = 0.446 \text{ m}$

$\lambda = 2L = 0.892 \text{ m}$

$$f = \frac{v}{\lambda} = \frac{338}{0.892} = 378.92 \text{ Hz}$$

(b)

Open pipe $\lambda = 2L$. Closed pipe $\lambda = 4L$. As $v = f\lambda$, velocity const, L const, the closed pipe has a larger (twice) wavelength, so the frequency will be less (half) than the open pipe ($f = 189.46$ Hz)

(c) *(Count 3 nodes.)* $n = 1138/379 = 3.0026$
Third harmonic