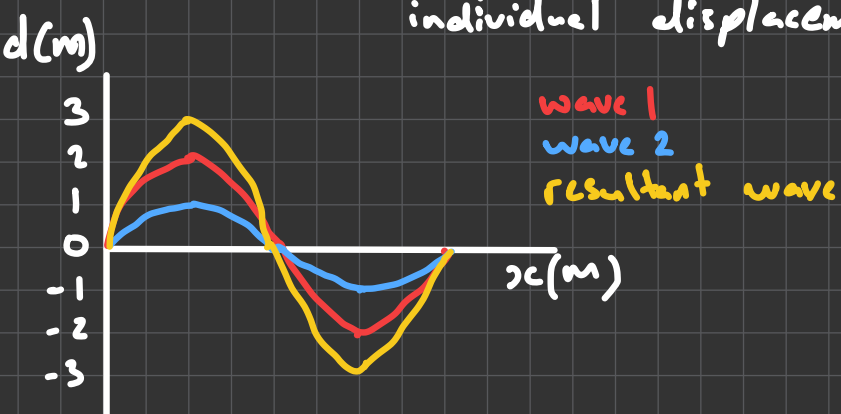


Superposition: when 2 waves interact the resultant displacement is the vector sum of the individual displacements



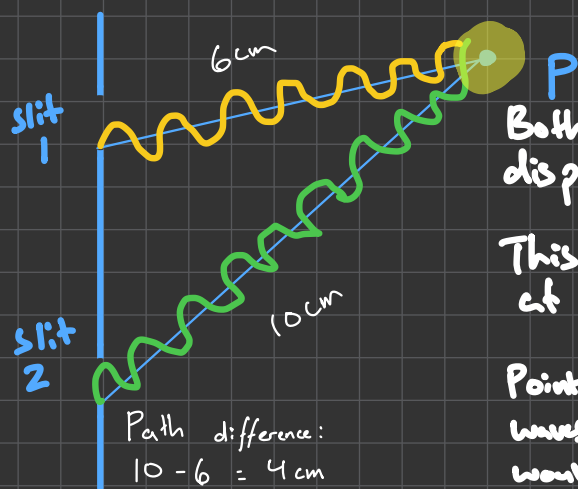
Phase difference: how far out of sync 2 points on a wave are

Phase difference = $\frac{x}{\lambda} \times 360^\circ$

$p.d. = \frac{1}{2} \times 360^\circ = 180^\circ$

$p.d. = \frac{1}{4} \times 360^\circ = 90^\circ$

Coherence: 2 waves are coherent if they have a constant phase difference.



Both waves reach point P at max displacement (amplitude).

This leads to constructive interference at point P

Point P becomes very bright as both waves meet peak to peak and they would add up.

Conditions for constructive interference:

- Phase difference between the waves is a multiple of 360° eg, 0, 360, 720 etc
- Path difference of the waves is an integer multiple of the wavelength

- Path difference = $n\lambda$ — wave length
integer

Conditions for destructive interference.

- Phase difference of 180°
ie waves must be in anti phase $n=0$
 $n=1$
etc
- Path difference = $(n + \frac{1}{2})\lambda$

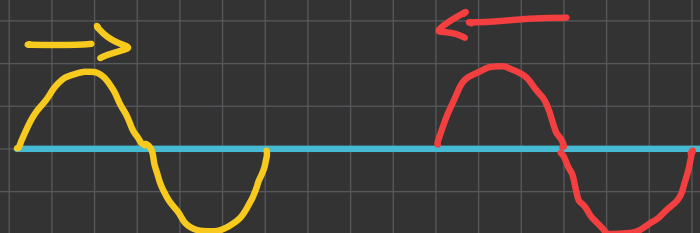
$p.d. = (0 + \frac{1}{2}) \times \lambda = 0.5 \text{ cm}$
 $p.d. = (1 + \frac{1}{2}) \times \lambda = 1.5 \text{ cm}$

Stationary waves
formation

Formed when two waves travel in opposite directions

Normally a wave is reflected off a fixed end.

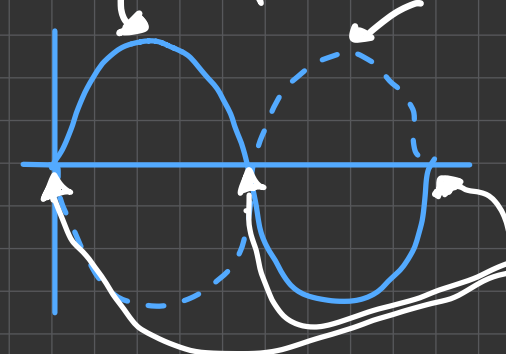
The two waves superpose (interfere) They create nodes and antinodes



Note: the two waves must have the same frequency and amplitude

A stationary wave is a superposition of 2 progressive waves

antinode - point of maximum amplitude



Node - point of zero amplitude

Phase difference in stationary waves

- Between adjacent nodes all the particles oscillate in phase
- Particles on opposite sides of a node are in antiphase, 180° out of phase

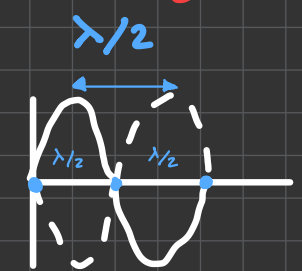
Stationary waves

No energy is transferred
Amplitude varies along the wave

Progressive waves

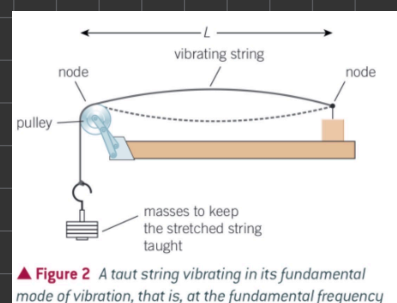
transfer energy in the direction of travel
Amplitude is constant across all points

Wave length in stationary waves



Distance between adjacent nodes (or antinodes)
= $\lambda/2$

Harmonics



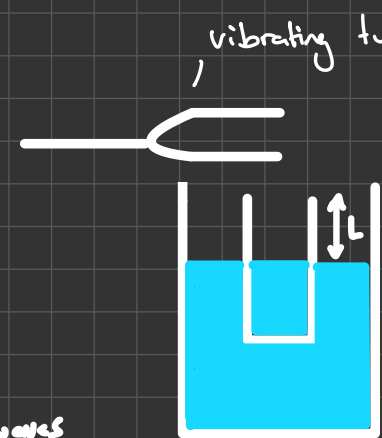
Only specific frequencies create stationary waves
These are known as harmonics

When the string is plucked a progressive wave travels along the string and reflects off its ends. This creates 2 progressive waves travelling in opposite directions that then form a stationary wave.

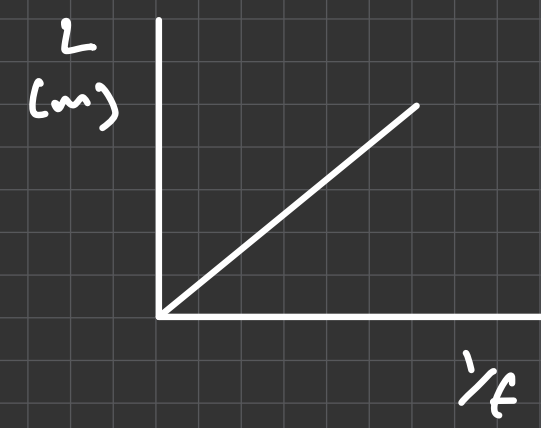
Harmonic	Shape	Frequency / Hz E.g	Frequency as a multiple of f_0	Wavelength of the progressive wave (where L is the length of the string)
1		20	f_0	$2L$
2		40	$2f_0$	L
3		60	$3f_0$	$\frac{2}{3}L$
4		80	$4f_0$	$\frac{1}{2}L$
5		100	$5f_0$	$\frac{2}{5}L$

Chapter 12
Waves 2
Page 2

Experiment to determine speed of sound



- Hold a tuning fork above a tube closed on one end
- The length of the tube can be changed by raising and lowering it in the water
- when you reach the first harmonic the length of the tube, $L = \frac{1}{4} \lambda$
- vary the frequency by using different tuning forks and measure the length at which you hear the harmonic
- Plot a graph of L against $1/f$



gradient, $m = \frac{L}{\frac{1}{f}} = \frac{\lambda/4}{1/f}$

gradient = $\lambda/4 \times f = \frac{f\lambda}{4}$

gradient = $\frac{v}{4}$

$v = \text{gradient} \times 4$

Stationary waves in air columns

1st
 $L = \frac{\lambda}{4}$

Node → antinode

Tube closed at one end

3rd
 $L = \frac{3}{4} \lambda$

Node → antinode

5th
 $L = \frac{5}{4} \lambda$

Node → antinode

Stationary waves in open tubes

1st

antinode → antinode

$L = \frac{\lambda}{2}$

2nd

antinode → node

$L = \lambda$

* harmonics go up in 2s for open closed air columns