* Stationary Waves *

Q-1) What is a stationary wave?

> When 2 progressive waves of the same wavelength, frequency and amplitude, travelling along the same path but in opposite directions superimpose, a stationary wave (standing wave) is produced.

① * It's made of nodes (minimum displacement) and antinodes (maximum displacement).

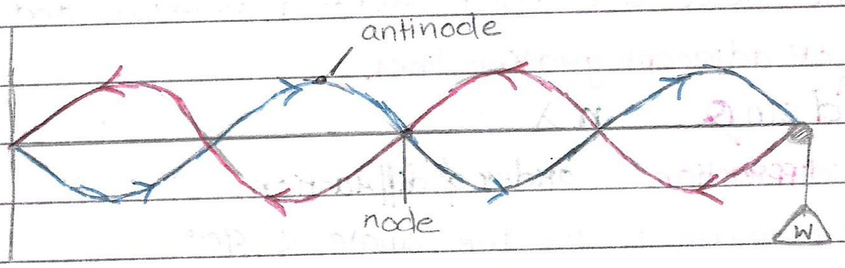
② * no energy is transported through the medium.

③ * All the particles vibrate with the same frequency / time period.

④ * Particles in the same loop are in the same phase. Particles in adjacent loops have a phase difference of 180° / π rad.

⑤ * The distance between 2 consecutive nodes / antinodes is λ/2.

⑥ * Each particle has a different amplitude.



Q-2) Distinguish between progressive and stationary waves.

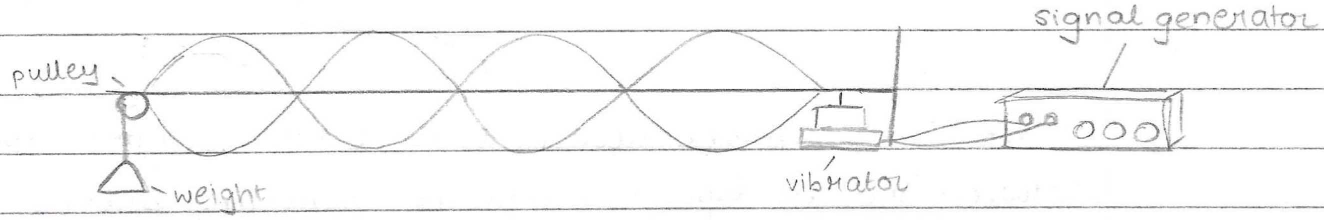
Progressive.	Stationary.
* energy is transferred through the medium.	* energy is not transferred
* The amplitude is the same (it's fixed)	* each particle has a different amplitude
* There's a phase difference between each particle.	* In a loop, particles have 0 phase difference. Between 2 consecutive phase difference is π (180°).

Q-3) Experiments to show formation of stationary waves.

(A) ROPE ON A STRING

Attach one end of a rope to a vibrator driven by a signal generator. The other end hangs over a pulley and weights maintain tension in the string. The wave will travel along the rope, and then will be reflected from the free end attached to the weights.

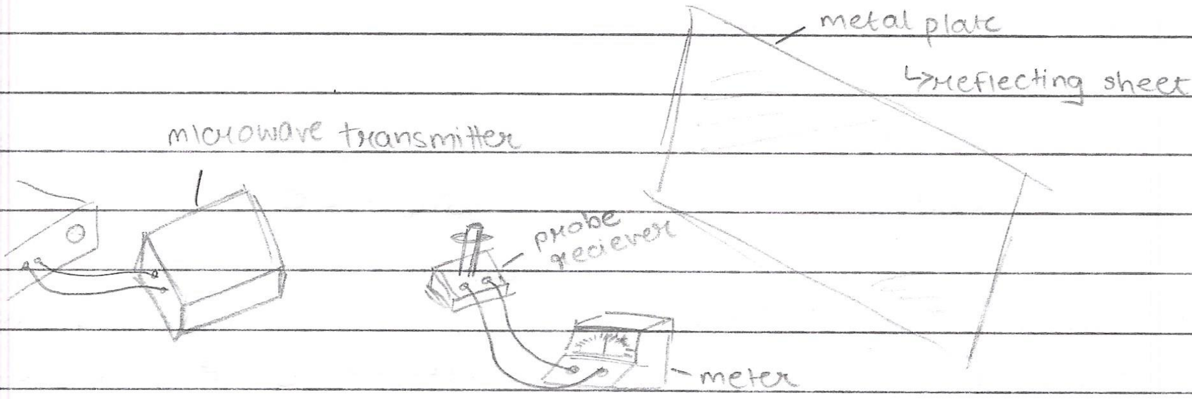
By adjusting the frequency of the vibrations, a stable pattern can be created.



A stroboscope is set to the same frequency as the vibrator, so the movement of the string can be seen in slow motion & it's easy to see the opposite movements of 2 adjacent loops.

(B) USING MICROWAVES

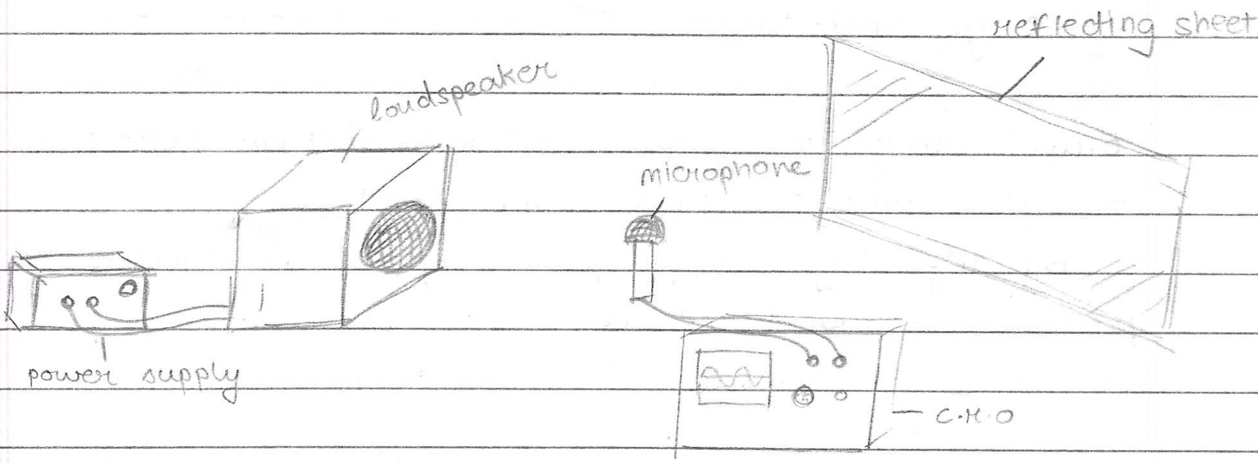
Direct a microwave transmitter at a metal plate, which will reflect the microwaves back to the source move a probe reciever in the space between the transmitter and the metal plate



Positions of high & low intensity will be observed. These will be the nodes and antinodes.

(C) USING SOUND WAVES

use a loudspeaker, connected to a power supply to generate longitudinal sound waves. Direct it at a reflecting sheet that will reflect the sound waves.



move a microphone, attached to a c.r.o, in the space between the loudspeaker and the reflecting sheet. The waveform can be observed on the c.r.o.

Q-4) What are free and forced vibrations?

Vibrations.

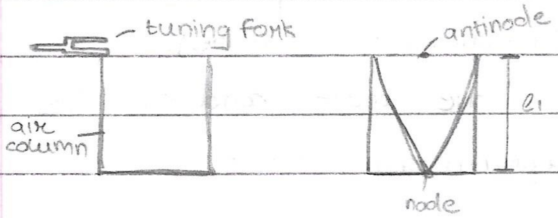
Free vibrations	Forced vibrations
> When a body capable of vibrating is once disturbed & left to itself, it performs free vibrations.	> To make a body vibrate at any desired frequency, we continually apply a force of that frequency. These are forced vibrations.
> The frequency of free vibrations is known as natural frequency.	> The amplitude of forced vibrations depends on the difference between the applied and natural frequency.

Q-5) What is resonance?

> Resonance is a particular case of forced vibrations when the applied frequency is equal to the natural frequency of the body. At resonance, the amplitude of the vibrations is maximum.

Q-6) Vibrations of air columns.

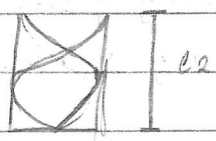
Air column closed at one end.



$l_1 = \lambda/4$

$\lambda = 4l_1$

$f_1 = v/\lambda = v/4l_1$ — fundamental frequency



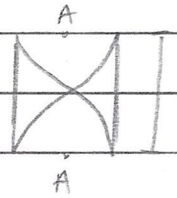
$l_2 = 3\lambda/4 = 3l_1$

$\lambda = \frac{4l_2}{3} = 12l_1$

$f_2 = \frac{3v}{4l_2} = \frac{v}{12l_1} = 3f_1$

Since the closed end will always have a node, and the open an antinode, odd harmonics are present.

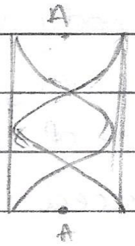
Air column ~~closed~~ open at both ends.



$l = \lambda/2$

$\lambda = 2l$

$f_1 = v/\lambda = v/2l$ → fundamental ~~node~~ frequency



$l = \lambda$

$\lambda = l$

$f_2 = v/l$

Both, ODD and EVEN harmonics are present.

$f_2 = \underline{\underline{2}} f_1$

second harmonic.

* Fundamental frequency is the simplest mode of vibrations.

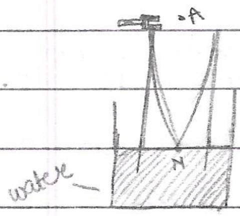
* Harmonics are multiples of the fundamental frequency.

Q-7) Finding speed of sound in air.

END CORRECTION

In case of a stationary wave formed in a tube, the antinode is formed slightly above the open end of the tube at a distance of 0·3d (d = diameter of tube).

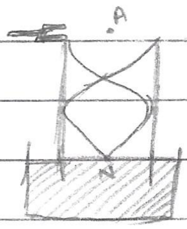
This is added to the length of the tube and can be eliminated by repeating the experiment twice.



$l_1 = \frac{\lambda}{4}$ ∴ $\lambda = 4l_1$

f = Frequency of air column = Frequency of tuning fork.

$v = f\lambda = f \times 4l_1$



$$l_2 = \frac{3\lambda}{4} \quad \therefore \lambda = \frac{4l_2}{3}$$

$$v = f\lambda = f \times \frac{4l_2}{3}$$

To eliminate end correction

① $\frac{\lambda}{4} = l_1 + e$

② $\frac{3\lambda}{4} = l_2 + e$

$$② - ① = \frac{\lambda}{2} = l_2 - l_1$$

$$\lambda = 2(l_2 - l_1)$$

$$v = f\lambda = f \times 2(l_2 - l_1)$$