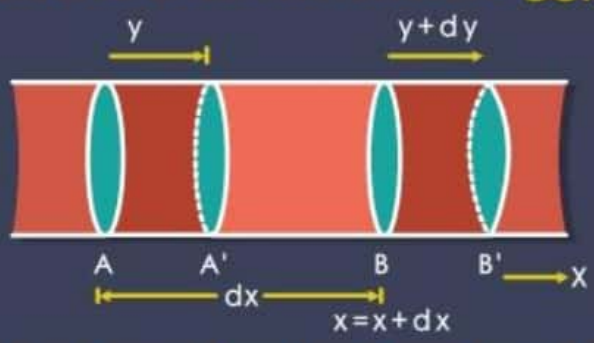
Part I

SOUND WAVE

PROPAGATION OF SOUND WAVES

Sound waves propagate in any medium through a series of periodic compressions and rarefactions of pressure, which is produced by the vibrating source.

COMPRESSION WAVES



When a longitudinal wave is propagated in a gaseous medium, it produces compression and rarefaction in the medium periodically.

Velocity and Acceleration of particle :

General equation of wave is given by

$$y = A \sin(\omega t - kx)$$

$$V_P = \frac{\partial y}{\partial t} = A\,\omega \cos(\omega t - kx)$$

VELOCITY OF SOUND/LONGITUDINAL WAVES IN SOLIDS

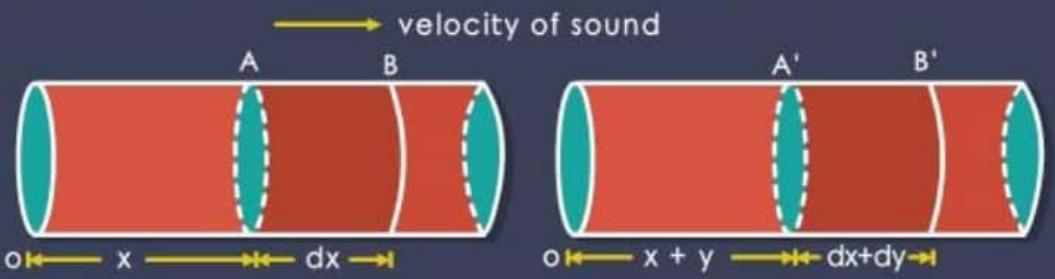
In Solid $v = \sqrt{\frac{Y}{\rho}}$

Y = Young Modulus

In Fluid $v = \sqrt{\frac{B}{\rho}}$

B = Bulk Modulus

In Gas $B = -V\frac{dP}{dV}$



Where,

P = Pressure

ρ = Density

V = Volume

T = Temperature

Newton's Formula for velocity of Sound in Gases, $v = \sqrt{\frac{P}{\rho}}$

Laplace Correction, $v = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{\gamma P}{\rho}}$

Effect of Temperature on Velocity of Sound, $\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$

Part II

LONGITUDINAL STANDING WAVES

Two longitudinal waves of same frequency and amplitude, travelling in opposite directions interfere to produce a standing wave.

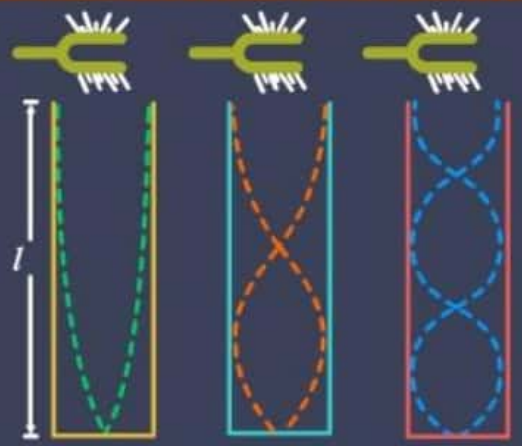
If the two interfering waves are given by:

$$p_1 = p_0 \sin(\omega t - kx) \text{ and } p_2 = p_0 \sin(\omega t + kx + \phi)$$

$$p = p_0 \sin\left(\omega t + \frac{\phi}{2}\right)$$

WAVES IN A VIBRATING AIR COLUMN

Vibration of Air in a Closed Organ Pipe



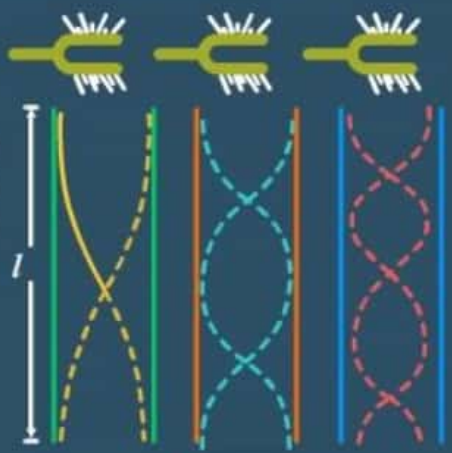
Fundamental frequency of oscillations of closed organ pipe of length l is given as

$$n_1 = \frac{v}{\lambda} = \frac{v}{4l}$$

- n_1 → Fundamental Frequency
- v → Velocity
- λ → Wavelength
- l → Length of organ pipe

Vibration of Air in Open Organ Pipe

$$\lambda = 2l$$



The fundamental frequency of organ pipe can be given as

$$n_1 = \frac{v}{\lambda} = \frac{v}{2l}$$

$$f = \frac{nv}{2l}$$

End Correction

The displacment antinode at an open end of an organ pipe lies slightly outside the open end. The distance of the antinode from the open end is called end correction and its value is given by

$$e = 0.6\,r$$

where r = radius of the organ pipe, and

$$f_{closed} = \frac{v}{4(l + 0.6r)} \qquad f_{open} = \frac{v}{2(l + 1.2r)}$$

Resonance Tube

This is an apparatus used to determine the velocity of sound in air experimentally and also to compare frequencies of two tuning forks.

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

Thus, sound velocity in air can be given as

$$v = n_0\lambda = 2n_0(l_2 - l_1)$$