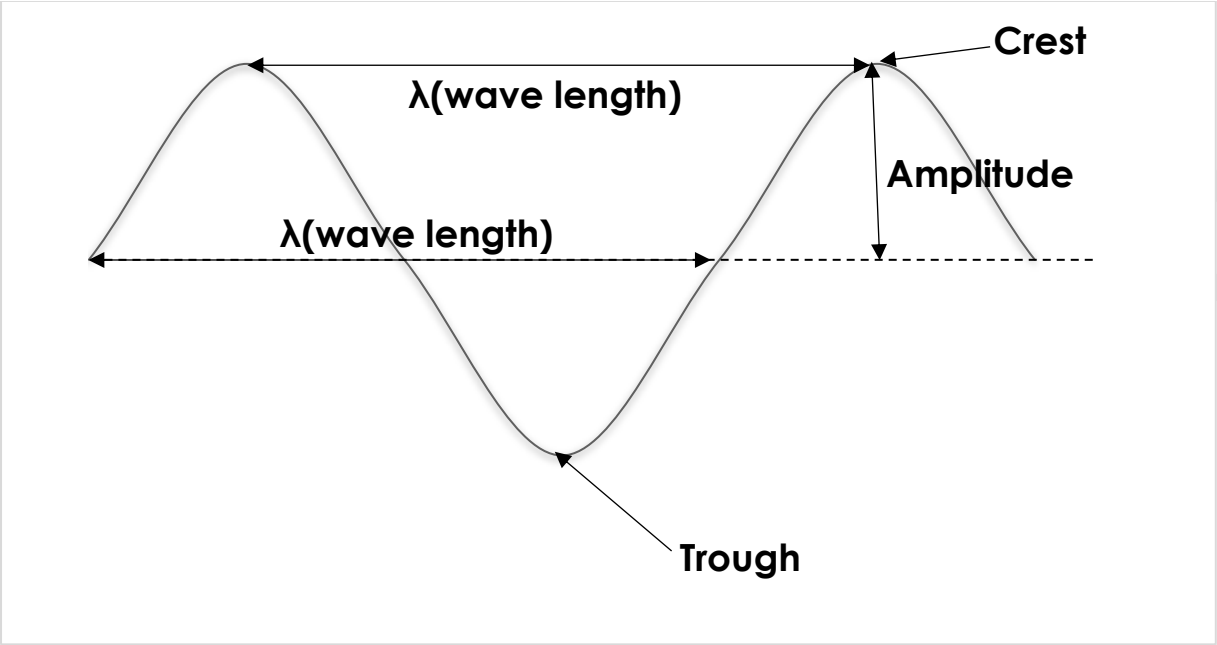
Mechanical Waves

- **Wave motion**



- The relation between Speed, Frequency and Wave length in Waves.

$$V = f\lambda$$

- **Classification of waves**

- Mainly we talk about *Transverse waves* and *Longitudinal waves.*

1. Transverse Waves

- In transverse waves, particles in the medium vibrates **perpendicular to the direction of wave**.

Eg : Electromagnetic waves

2. Longitudinal Waves

- Briefly… A wave that travels because of vibrating the particles in the medium **parallelly to its direction**.
  Eg : Sound waves

- **Properties of waves**

- **Reflection** – If a wave changes its direction back to the same medium when it meets a surface, we can say the wave was reflected.

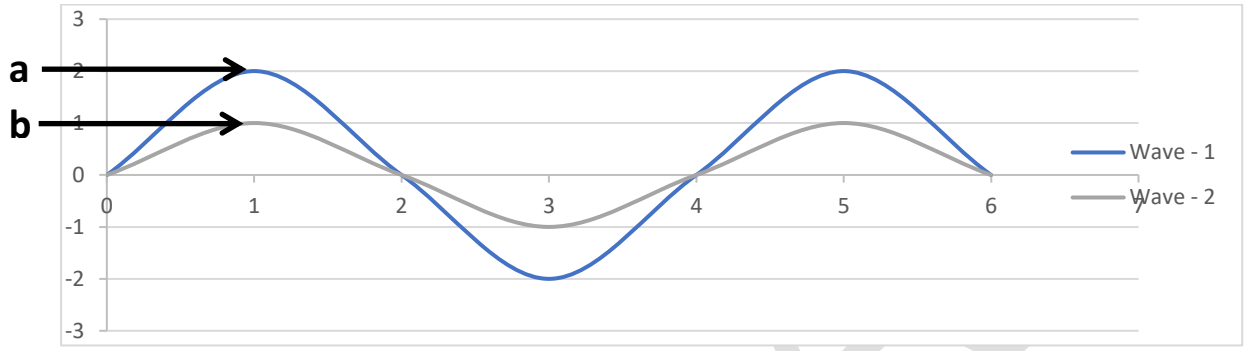
- **Refraction** – If a wave changes its and enter the next medium, then we can say " the wave Refracted".

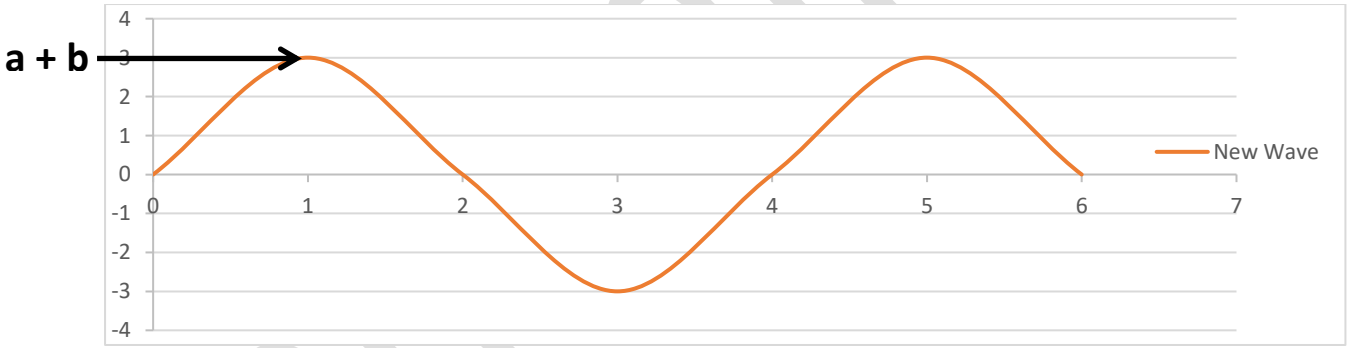
- **Diffraction** – When a wave passes an edge or an aperture , the wave will be spread. This is called as Diffraction.

- **Wave Interference** – This happens when 2 waves meet in the same medium. This could happen in 2 main ways.

1. Constructive Interference

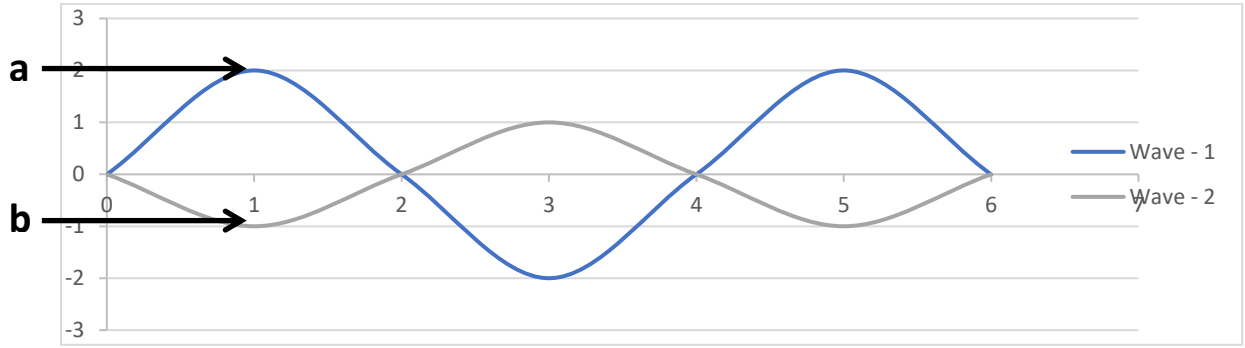
- When 2 waves have the displacements of same direction wave amplitude will be amplified.

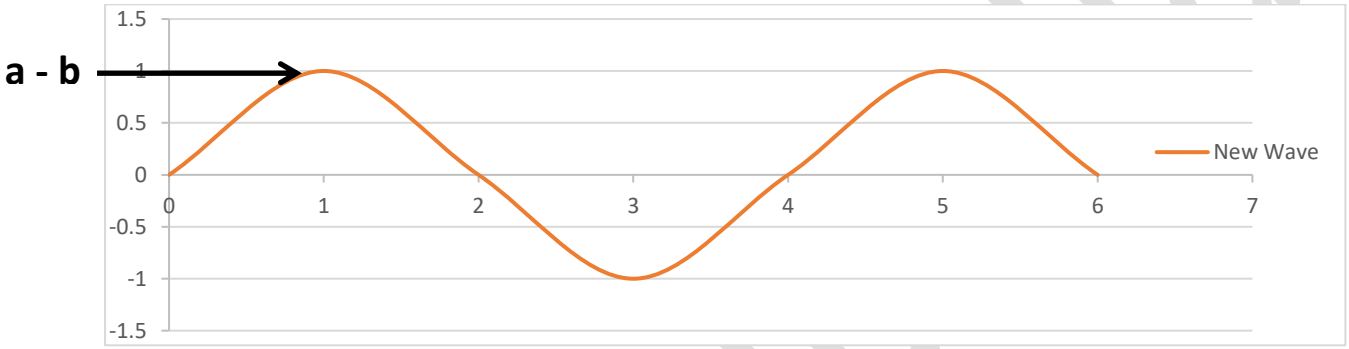




2. Destructive Interference

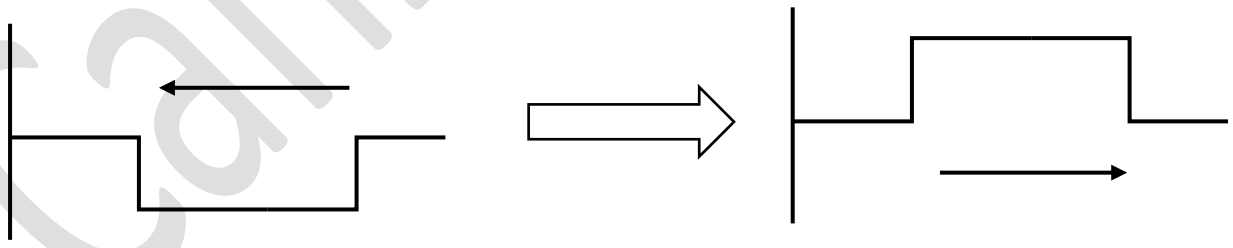
- When 2 waves have the displacements of opposite direction, wave amplitudes will be reduced.



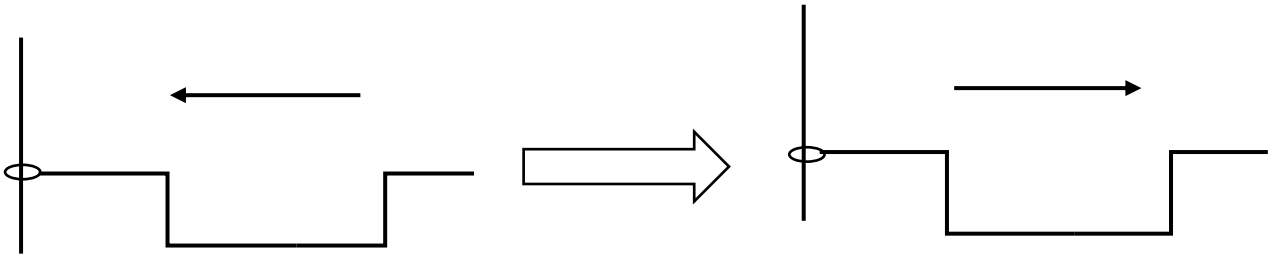


- **Reflections of waves**

1. In a fixed end.

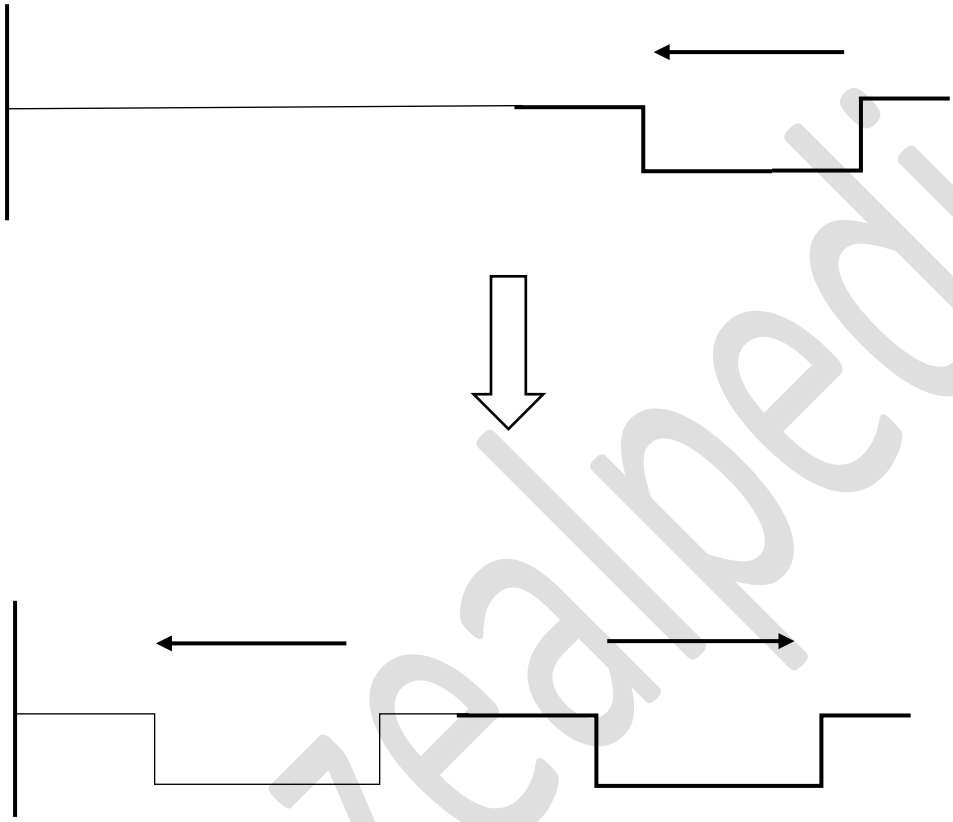


2. In a free end.

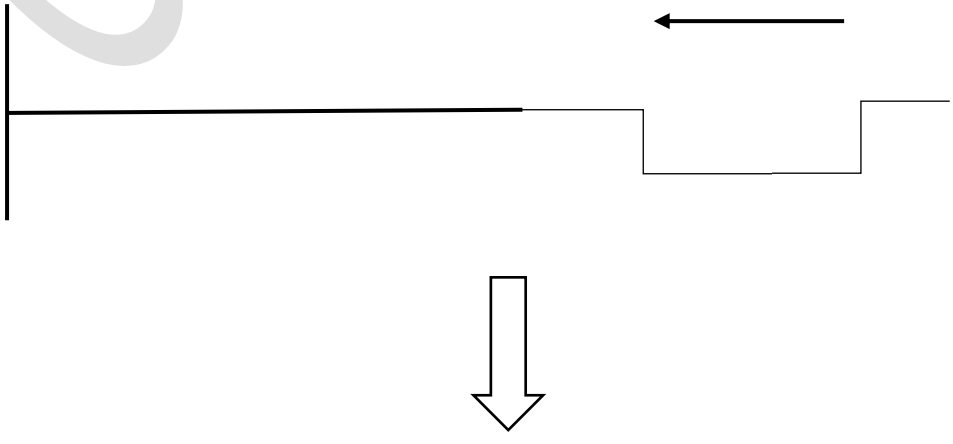


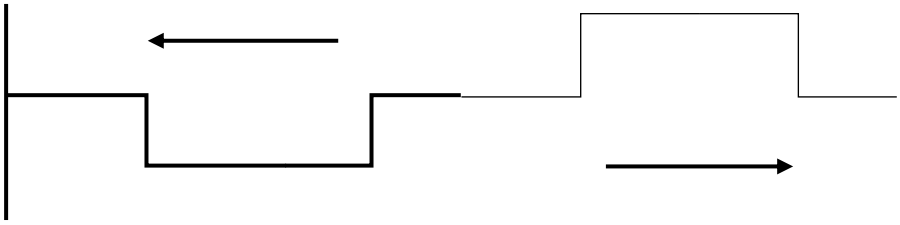
3. In connected strings

   I. High density to low density



   II. Low density to high density

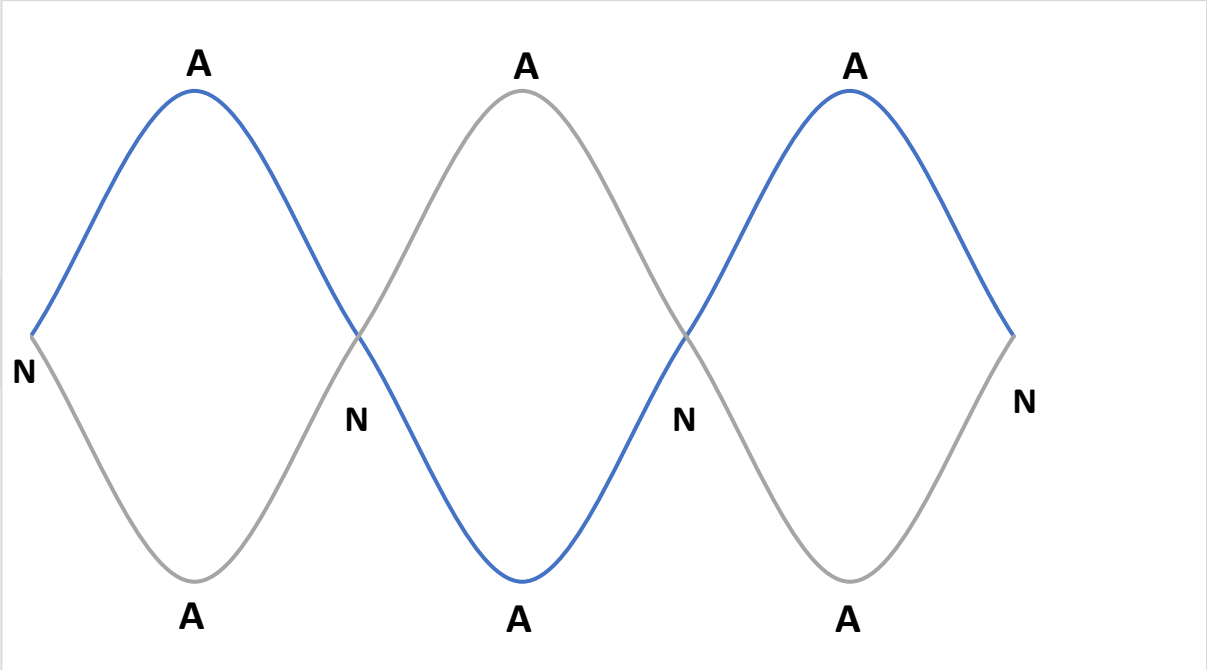




- **<u>Standing Waves (Stationary waves)</u>**

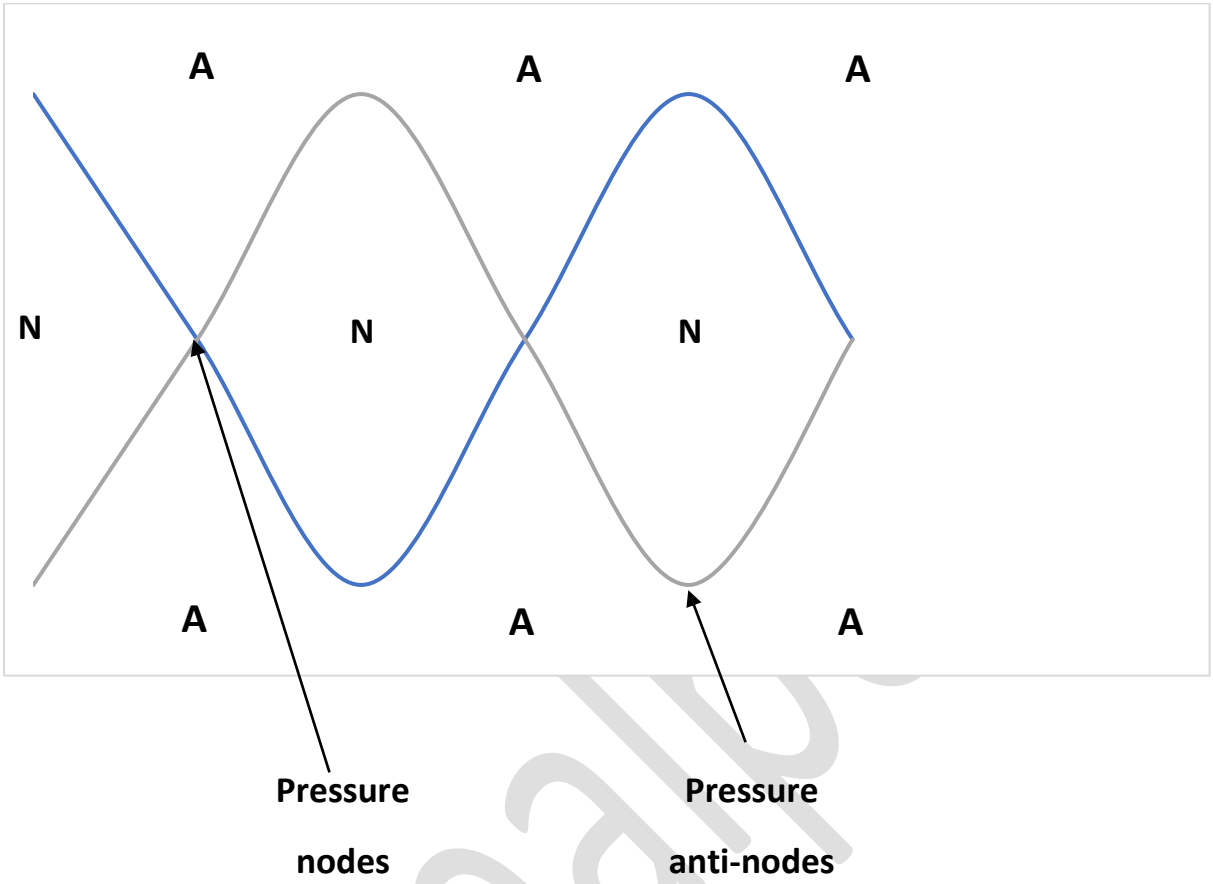
  - Standing waves generates when 2 same waves (same amplitude, same frequency) travel opposite directions in a same medium.

    However, the amplitude will not move.



N = Nodes A = Anti-nodes

➢ How pressure changes when there is a standing wave.



(Use N and A to imagine how the standing wave was)

- **<u>Vibrations in strings, rods and tubes</u>**

  - <u>Speed of a transverse wave in a string</u>

$$v = \sqrt{\frac{Tl}{m}}$$

T = Tension of the string

l = Length of the string

m = Mass of the string

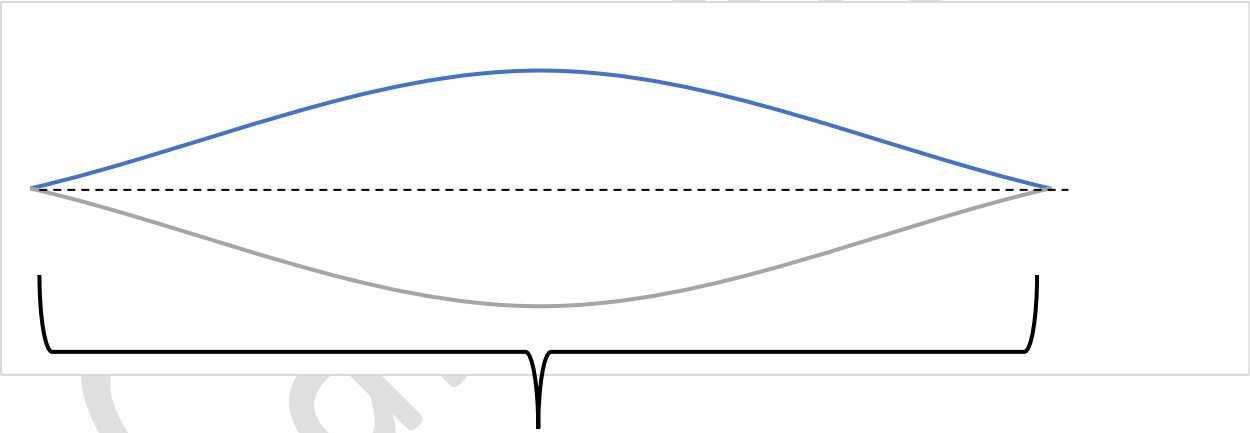
But, $\frac{m}{l}$ = **M** (Mass per length)

So,

$$\mathbf{V} = \sqrt{\frac{T}{M}}$$

- **<u>Stationary transverse waves in a String</u>**

1. 1st Harmonic / Fundamentals



$$\mathbf{l} = \frac{\lambda}{2}$$

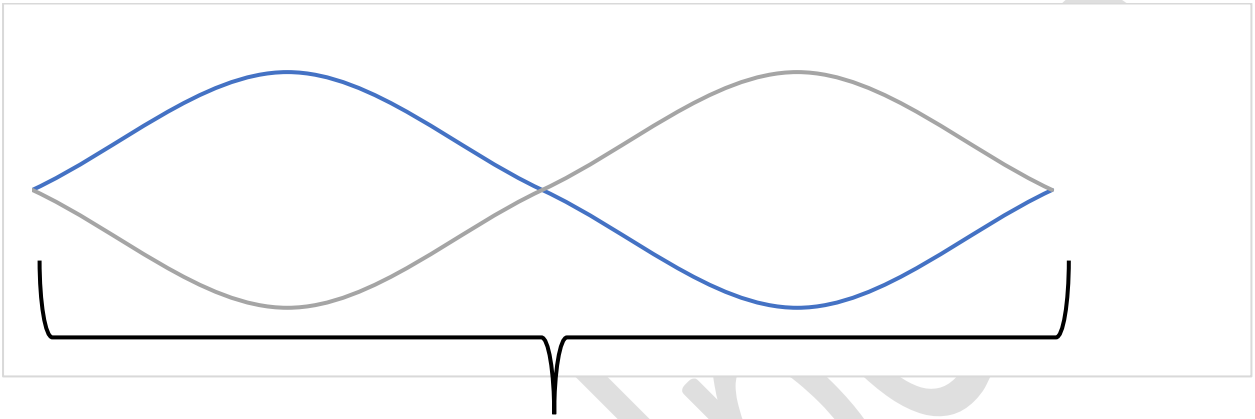
$\lambda = 2l$

$V = f\lambda$

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

$$f = \frac{1}{2l}\sqrt{\frac{T}{M}}$$

2. 2nd Harmonic / 1st Overtone



l = λ

Calculate yourself from here…and see how other harmonics change.

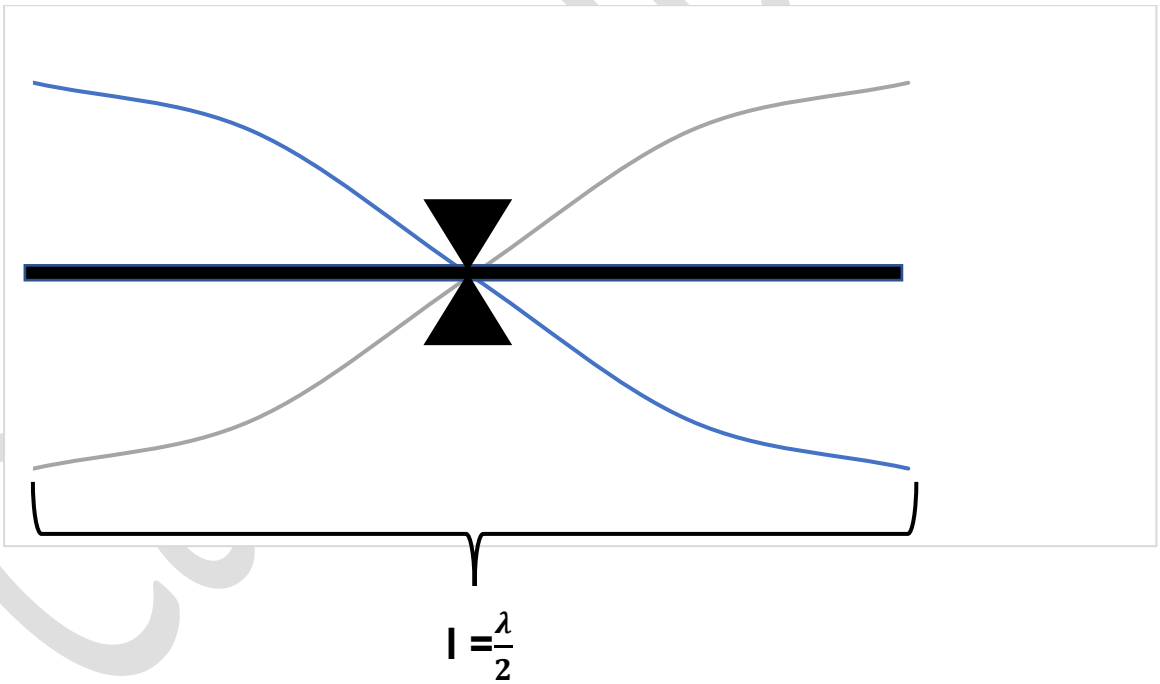
- **Stationary longitudinal waves in a Rod**
  - Speed of a longitudinal wave in a rod

$$V = \sqrt{\frac{Y}{\rho}}$$

Y = Young's Modulus

ρ = Density

1. Clamped in the middle



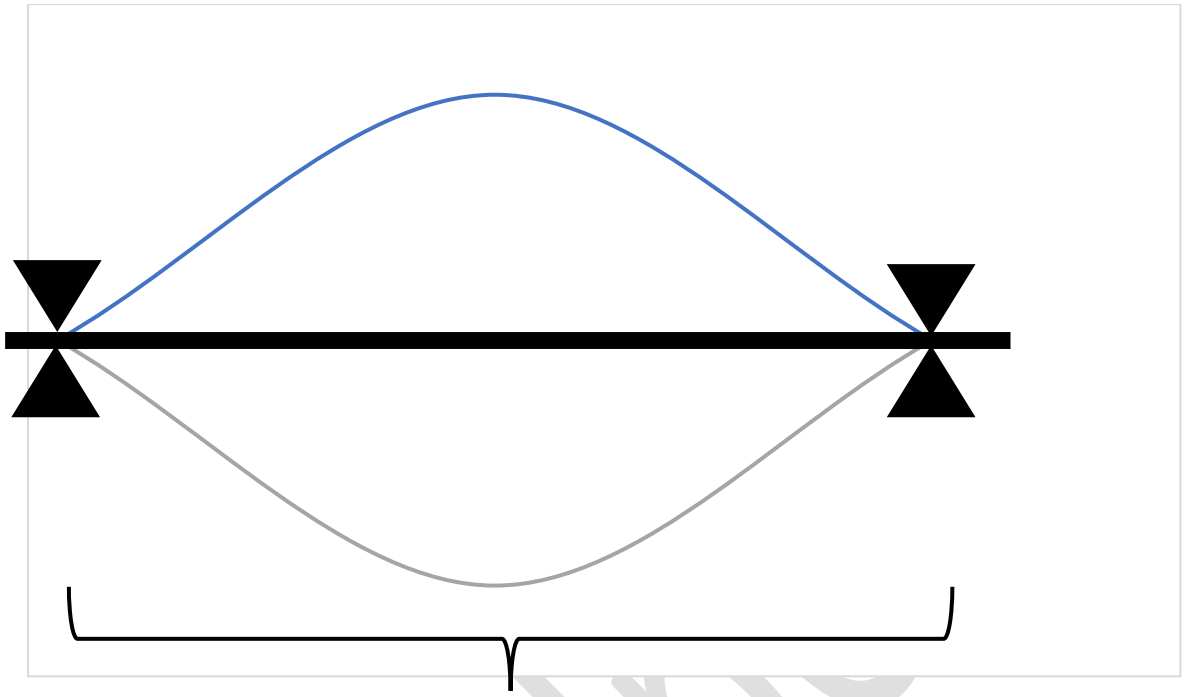
$$l = \frac{\lambda}{2}$$

$\lambda = 2l$ and $V = \sqrt{\frac{Y}{\rho}}$. Also, $f = \frac{V}{\lambda}$

So,

$$f = \frac{1}{2l}\sqrt{\frac{Y}{\rho}}$$

2. Clamped at both ends



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

- **<u>Stationary longitudinal waves in open tubes</u>**

  - Speed of a longitudinal wave in a Gas

$$V = \sqrt{\frac{\gamma P}{\rho}}$$

γ = Heat capacity ratio(Adiabatic index)

P = Pressure

ρ = Density of the gas

Note : In questions you will have to use other gas-based formulas to make a useful equation for your question.

Eg: PV = nRT and $\rho = \frac{m}{v}$

$$\mathbf{V} = \sqrt{\frac{\gamma PV}{m}}$$

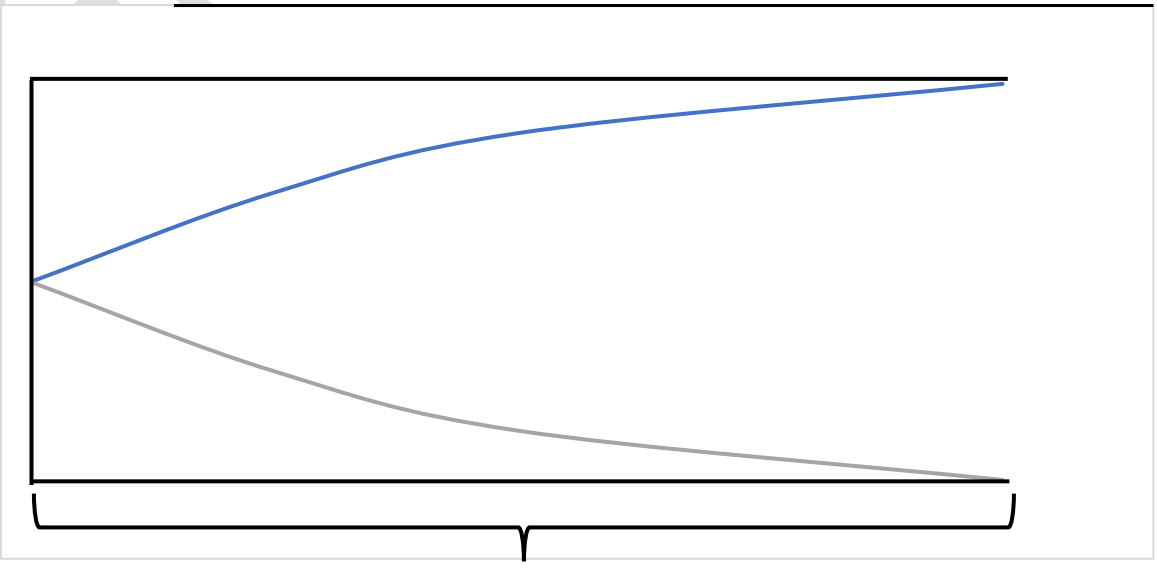
$$\mathbf{V} = \sqrt{\frac{\gamma nRT}{m}}$$

- **Direction**

Go to Oscillations and Mechanical waves → Easy Patterns to learn more stuffs about how wave speed changes in gases.

1. One side closed Tube

   I. Fundamental / 1st Harmonic



$$\mathbf{l} = \frac{\lambda}{4}$$

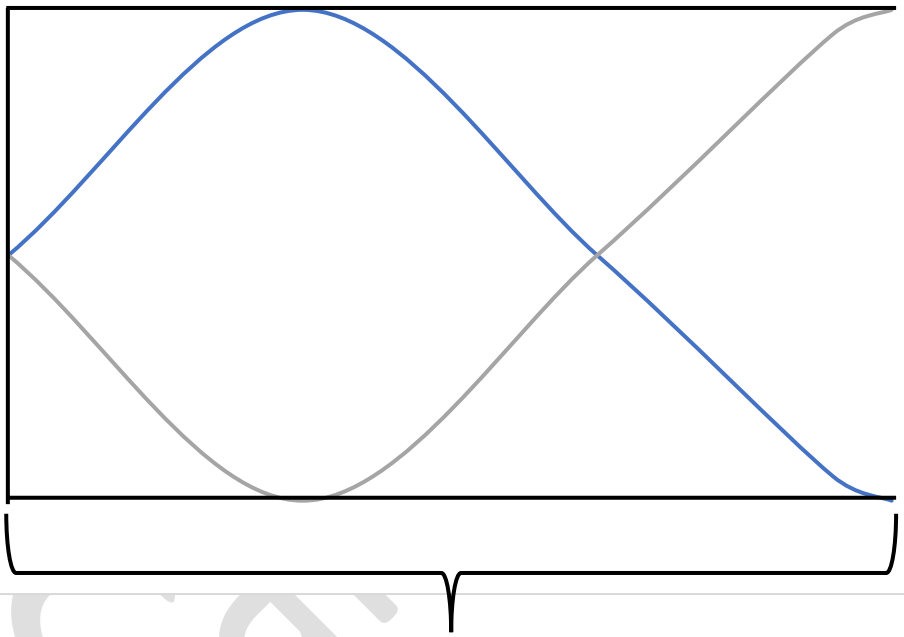
$\lambda = 4l$

$v = \sqrt{\frac{\gamma P}{\rho}}$

$V = f\lambda$

$$\boldsymbol{f = \frac{1}{4l}\sqrt{\frac{\gamma P}{\rho}}}$$

II. 1st Overtone / 3rd Harmonic

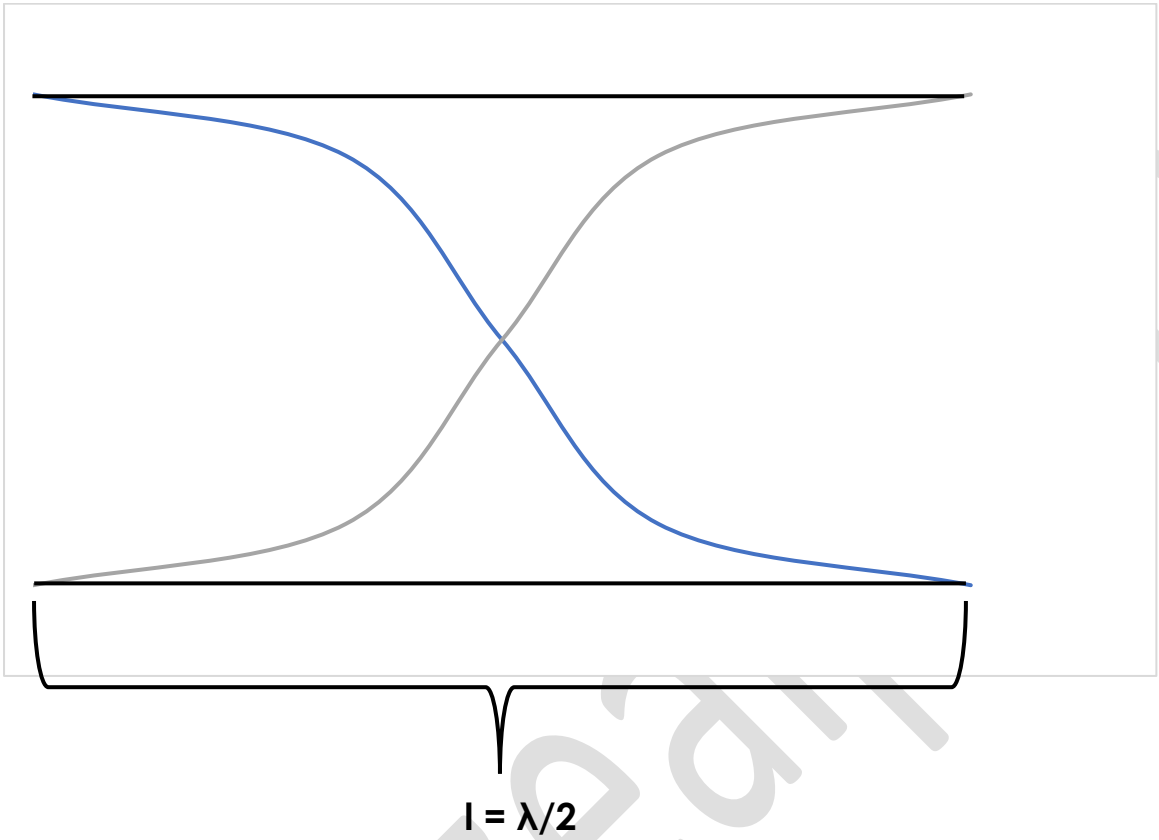


$$\boldsymbol{l = \frac{3\lambda}{4}}$$

- Look carefully about the red colored letters. Do your calculations yourself and see how other Harmonics change.

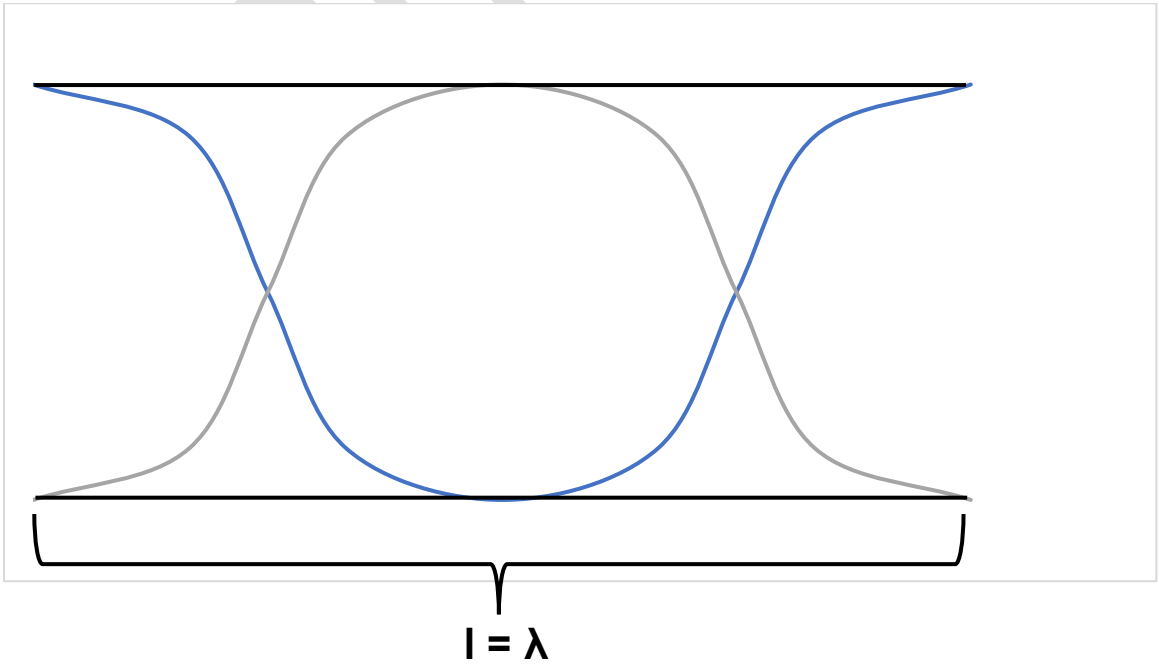
2. Both sides opened Tube

I. Fundamental / 1st Harmonic



l = λ/2

2. 1st Overtone / 2nd Harmonica



l = λ