LAKSHYA

MHTCET 2025

Physics | Lecture - 04

Superposition of Waves

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Topics *to be covered*

1. End Correction ✓
2. Laws of Vibrating String ✓
3. Sonometer ✓
4. Beats ✓
5. Characteristics of Sound ✓
6. Musical Instrument ✓

Revision :

1) Stationary wave

2) Closed Pipe, Open Pipe & String.

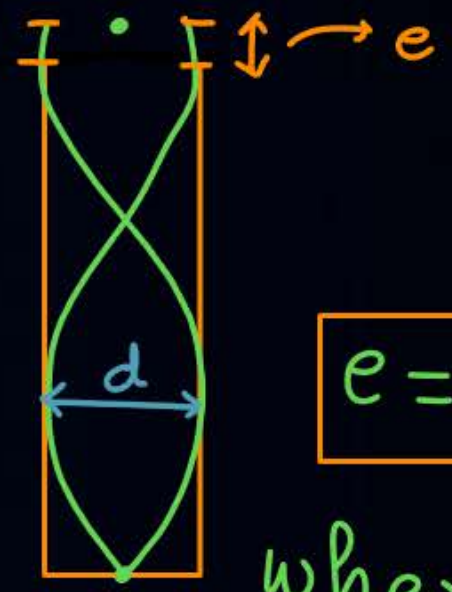
3) Harmonics & Overtones.

$L = l + e$

Closed pipe	Open pipe	String
$n = V/4L$	$n = V/2L$	$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$
$n_2 = 3n$	$n_1 = 2n$	$n_1 = 2n$
$n_3 = 5n.$	$n_2 = 3n$	$n_2 = 3n$

End Correction

The antinode of a stationary at the open end of pipe not form exactly at its opening but it forms just above it that small distance is c/a End Correction.



$$\boxed{e = 0.3d}$$

where
d - inner diameter of tube.

Laws of a Vibrating String

Formula for frequency of vibrating string is given by.

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}.$$

where l – length of string

T – Tension in string

m – Mass per unit length

$$\boxed{m = \frac{M}{L}}$$

1) Law of length :

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

$n \propto \frac{1}{l}$ if T & m = const.

$$n_1 l_1 = n_2 l_2 = \text{const}$$

2) Law of Tension :

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

$n \propto \sqrt{T}$ if

l & m is const

$$\frac{n_1}{\sqrt{T_1}} = \frac{n_2}{\sqrt{T_2}} = \text{const.}$$

3) Law of Linear Density:

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

$$n \propto \frac{1}{\sqrt{m}} \text{ if}$$

T & l is const.

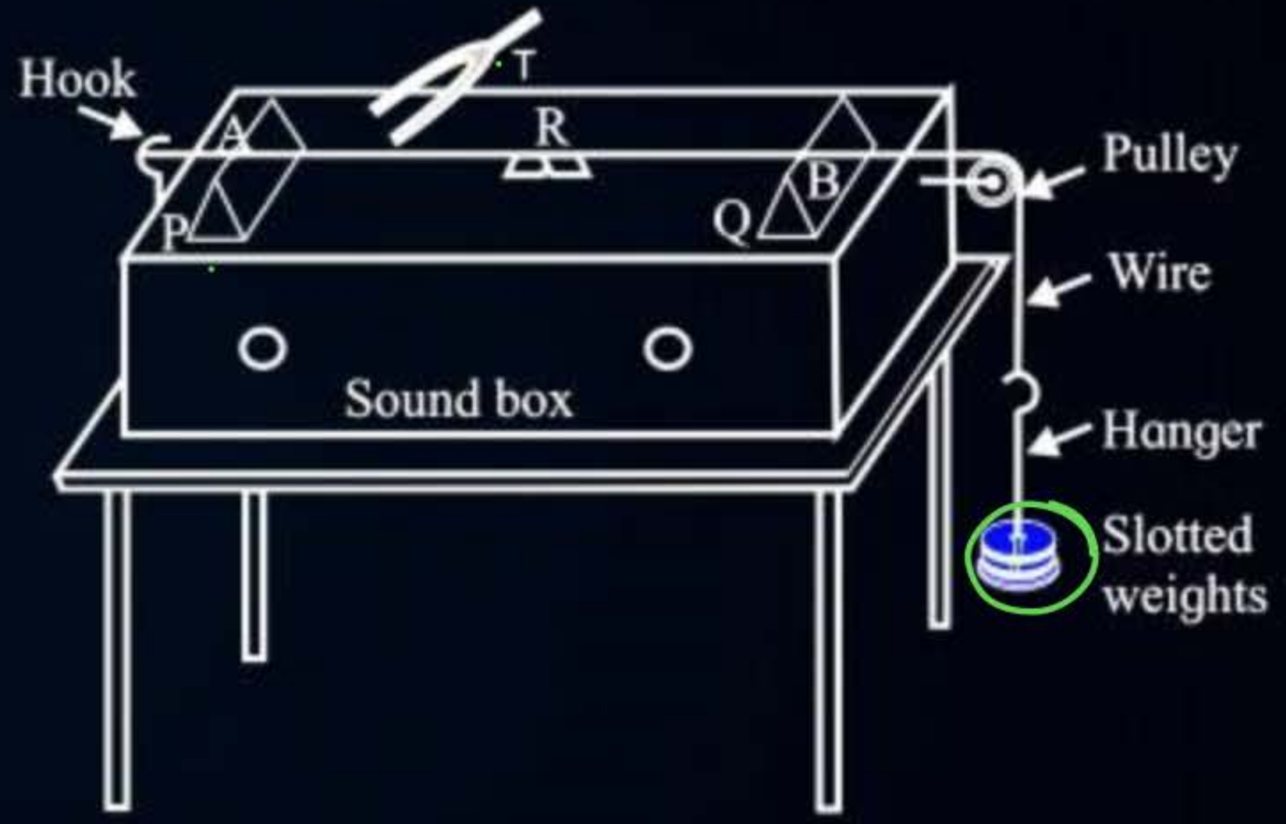
$$n \propto \frac{1}{\sqrt{\pi r^2 \rho}}$$

$$\therefore n \propto \frac{1}{\sqrt{\rho}}$$

$$\therefore n \propto \frac{1}{r}$$

Sonometer

- It is the instrument which is used to validate laws of vibrating string.



Beats

When two sound waves travelling in same direction but having slightly different frequency superimpose, the periodic waxing & waning sound occurs. This is c/a production of beats.

One waxing & waning is c/a one beat.

$$y_1 = a \sin 2\pi\left[n_1 t - \frac{x}{\lambda_1}\right]$$

$$y_2 = a \sin 2\pi\left[n_2 t - \frac{x}{\lambda_2}\right]$$

$$y = y_1 + y_2$$

$$y = y_1 + y_2$$

$$y = a\left[\sin 2\pi\left[n_1 t - \frac{x}{\lambda_1}\right] + \sin 2\pi\left[n_2 t - \frac{x}{\lambda_2}\right]\right]$$

By using formula

$$\sin C + \sin D = 2 \sin\left(\frac{C+D}{2}\right) \cos\left(\frac{C-D}{2}\right)$$

Let the listner be at origin $\therefore x = 0$

$$y = a\left[\sin 2\pi n_1 t + \sin 2\pi n_2 t\right]$$

$$\therefore y = \underline{2a} \sin 2\pi \left[\frac{n_1+n_2}{2}\right]t \cdot \underline{\cos 2\pi \left[\frac{n_1-n_2}{2}\right]t} .$$

$$y = \underbrace{2a \cos \left[\frac{n_1-n_2}{2}\right]t} \cdot \sin 2\pi \left[\frac{n_1+n_2}{2}\right]t$$

$$y = A \sin 2\pi n t$$

$$\boxed{y = A \sin \omega t}$$

where $n = \frac{n_1+n_2}{2}$

$$A = 2a \cos 2\pi \left[\frac{n_1-n_2}{2}\right]t$$

<u>for waxing:</u>

$$A = \pm 2a .$$

$$\therefore \cancel{2}\cancel{a} \cos 2\pi \left[\frac{n_1-n_2}{2}\right]t = \pm \cancel{2}\cancel{a}$$

$$\therefore \cos 2\pi\left[\frac{n_1-n_2}{2}\right]t = \pm 1$$

$$\cancel{2}\pi\left[\frac{n_1-n_2}{\cancel{2}}\right]t = 0, \pi, 2\pi, 3\pi$$

$$(n_1-n_2)t = 0, 1, 2, 3$$

$$t = 0, \frac{1}{n_1-n_2}, \frac{2}{n_1-n_2}, \frac{3}{n_1-n_2}$$

this is the time where waxing Sound is there.

$$\therefore T = \frac{1}{n_1-n_2} - 0$$

$$T = \frac{1}{n_1-n_2}$$

$$\boxed{N = n_1 - n_2}$$

— formula for beat frequency.

for Minima :

$$A = 0$$

$$2a\cos 2\pi\left[\frac{n_1 - n_2}{2}\right]t = 0$$

Home work.

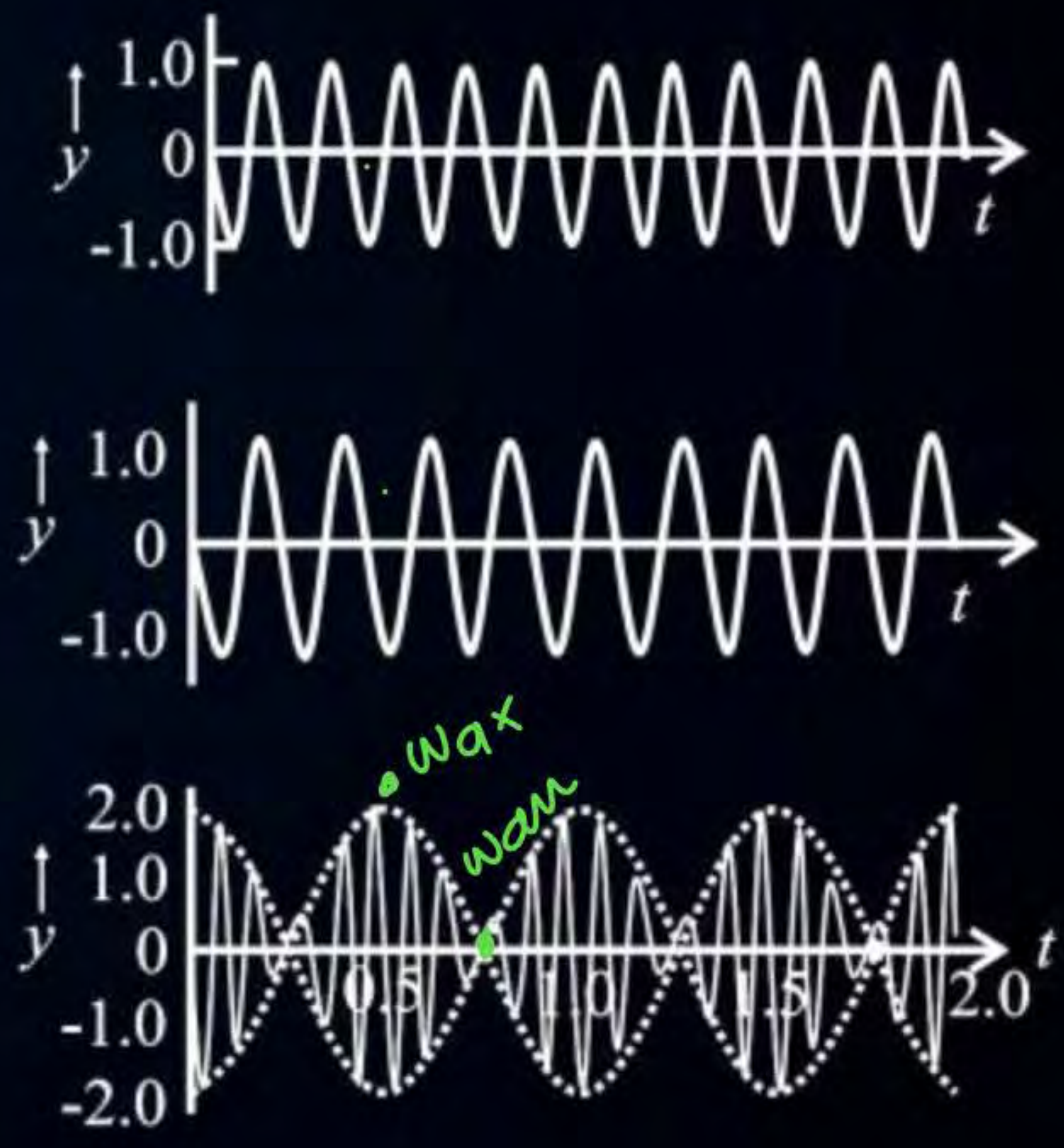
$$t = \frac{1}{2(n_1 - n_2)}, \frac{3}{2(n_1 - n_2)}, \frac{5}{2(n_1 - n_2)}$$

$$T = \frac{1}{n_1 - n_2}$$

$$\boxed{N = n_1 - n_2}$$

— Beat frequency.

Analytical method to determine beat frequency



Summary

1) End correction. $e = 0.3d$.

2) Laws of vibrating string.

3) Sonometer

4) Beats

Homework

1) Revise all Lectures

2) Revise all Dpp's

3) Read characteristics of sound & Musical Instrument.

धन्यवाद