To Study the Relation Between Frequency and Length of a Given Wire Under Constant Tension Using Sonometer

Aim

To study the relation between frequency and length of a given wire under constant tension using sonometer.

Apparatus

A sonometer, a set of eight tuning forks, 1\2 kg hanger, seven 1\2 kg slotted weights, rubber pad, paper rider, metre scale, screw gauge.

Theory

If stretched wire (string) vibrates in resonance with a tuning fork of frequency v, then the string also has same frequency v.
If the string has a length l, diameter D, material of density p and tension T, then

$$\nu = \frac{1}{lD}\sqrt{\frac{T}{\pi\rho}} \qquad \ldots(1)$$

Relation between frequency (ν) and length (*l*). From Eq. (1) above, $\nu \propto \frac{1}{l}$

or $\nu l = \text{Constant}.$

A graph between ν and $\frac{1}{l}$ will be a straight line, while a graph between ν and l will be a hyperbola.

Relation between length (*l*) and tension (*T*). From Eq. (1) above,

$$\frac{\sqrt{T}}{l} = \text{Constant}$$

or $\sqrt{T} \propto l$

or $T \propto l^2$

A graph between T and l^2 will be a straight line.

Diagram

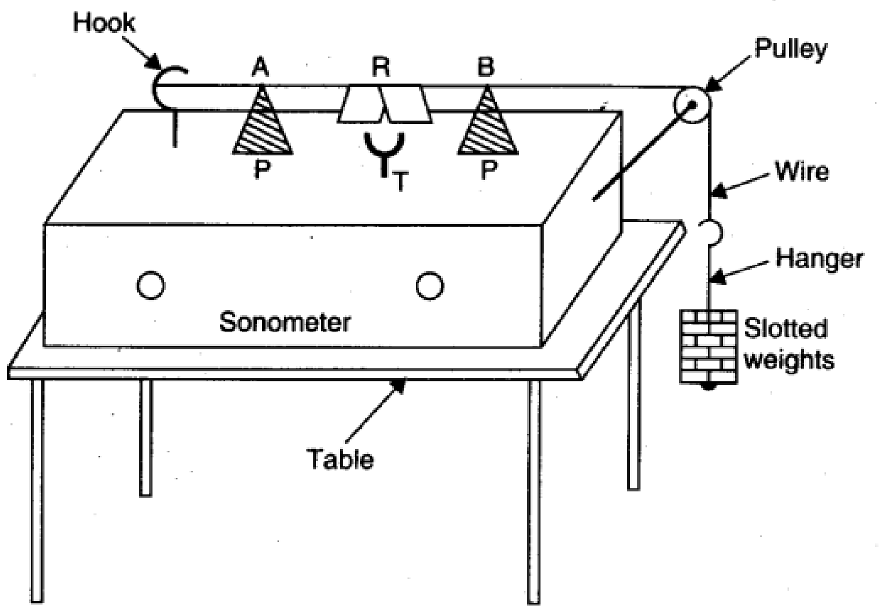


Fig. Sonometer in experimental set up.

Procedure (To find the relation between frequency and length)

1. Place the sonometer on the table as shown in Fig.
2. Test the pulley and make it frictionless by oiling (if necessary).
3. Put suitable maximum weight in the hanger.
4. Move wooden bridges P, outward to include maximum length of wire (AB) between them.
5. Take a tuning fork of least frequency from among the set. Strike its prong with a rubber pad to make it vibrate. Bring the tuning fork near your ear.
6. Pluck the wire AB from the middle and leave it to vibrate.
7. Listen sound produced by tuning fork and wire and judge which has less frequency (sound which is grave and has low pitch, has less frequency).
8. Since the long wire may have less frequency, decrease its length by moving the bridges inwardly. Check the frequencies again.
9. Go on decreasing the length till frequency of vibrating wire AB becomes equal to the frequency of the tuning fork.
10. Put an inverted V shape paper rider R on the wire AB in its middle. Vibrate the tuning fork and touch the lower end of its handle with sonometer board. The wire AB vibrates due to resonance and paper rider falls.
11. Note the length of the wire AB between the edges of the two bridges and record it in ‘length decreasing’ column.
12. Bring the two bridges closer and then adjust the length of the wire by increasing it little by little till rider falls.
13. Note the length of the wire and record it in ‘length increasing’ column.

14. Take the remaining five tuning forks, one by one, in order of increasing frequency and repeat steps 5 to 13.
15. Record your observations as given below.

Observations

Constant tension on the wires, T =…………kg.

Table for frequency and length

Serial No. of Obs.	*Frequency of tuning fork used* ν *(Hz)*	*Resonant length of wire*			$\frac{1}{l}$ (cm^{-1})
		Length increasing l_1 *(cm)*	*Length decreasing* l_2 *(cm)*	*Mean* $= \frac{l_1 + l_2}{2}$ l *(cm)*	
1.	256	50.1	49.9	$= \frac{50.1 + 49.9}{2}$ $= 50$	0.02
2.	288				
3.	320				
4.	384				
5.	480				
6.	512				

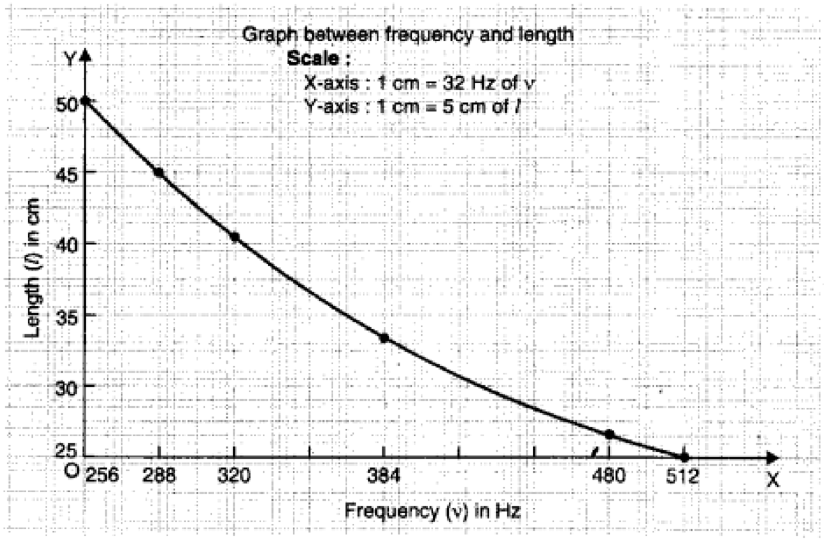
(**Note.** *Observation 1 is as sample*)

Calculations

1. Find mean length l.

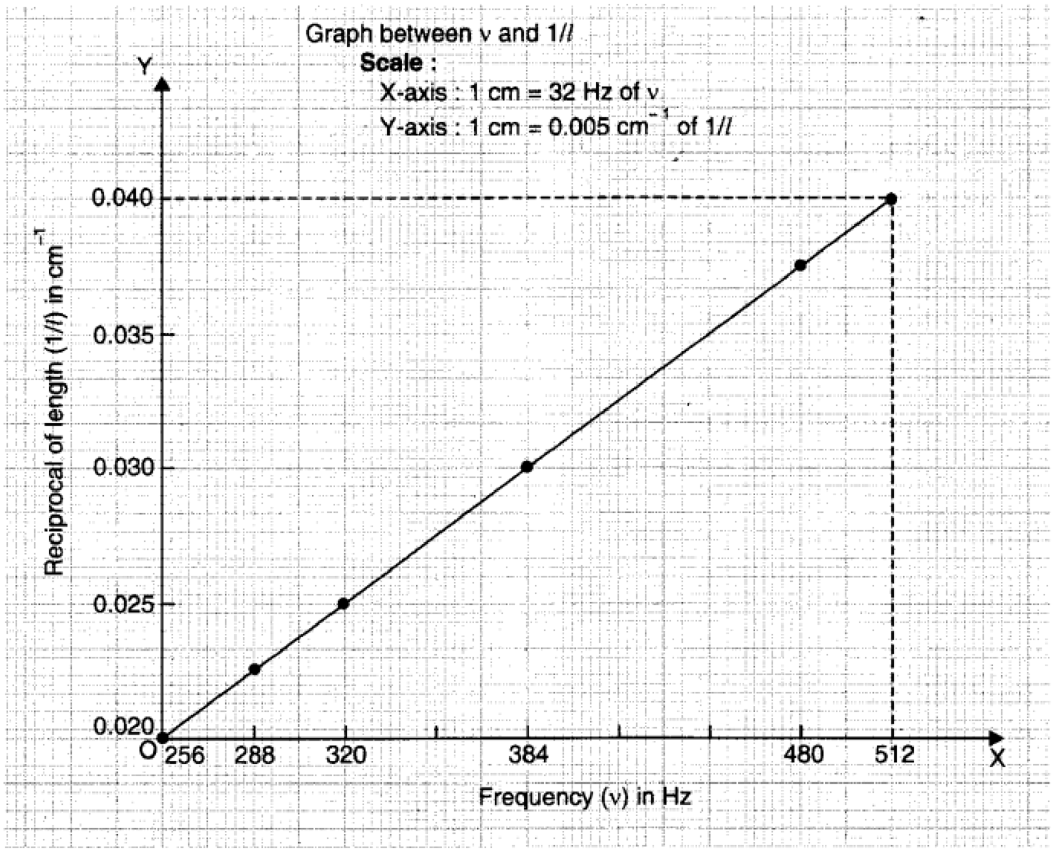
2. Find $\frac{1}{l}$.

3. Plot a graph between ν and l, taking ν along X-axis and l along Y-axis.



Graph between frequency (ν) and length l. It is a hyperbola.

4. Plot a graph between ν and $\frac{1}{l}$, taking ν along X-axis and $\frac{1}{l}$ along Y-axis. The graph comes to be a straight line as shown in below.



Graph between ν and $1/l$. It is a straight line.

Result

From the graph, we conclude that νl = constant and $\nu \propto \frac{1}{l}$.

This verifies law of length of transverse vibrations of strings.