*Experiment No. 03*

**Name of the Experiment: Determination of the frequency of a tuning fork by Melde's apparatus.**

## Theory:

When a tuning fork is excited and held near a stretched string, transverse vibrations are propagated along the string with a velocity,

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

Where, $T$ is the tension of the string and $m$ is its mass per unit length. If the plane of vibration of the fork is perpendicular to the string, the frequency of vibration of the string is equal to that of the fork, while if they are parallel, the frequency is half that of the fork. The wavelength is therefore $\lambda = \frac{v}{f}$ for perpendicular vibrations and $\lambda = \frac{2v}{f}$ for parallel vibrations, where $f$ represents the frequency of the fork.

For a given tension $T$, if the length of the string is properly adjusted so as to make its total length equal to an integral multiple of $\lambda/2$, then the stationary wave pattern will be formed. If $l$ be the length of a single loop (distance between successive nodes), then when the fork vibrates perpendicular to the string, the value of $l$ is given by the relation,

$$l = \frac{\lambda}{2} = \frac{v}{2f} = \frac{1}{2f}\sqrt{\frac{T}{m}}$$

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

When the fork vibrates parallel to the string, then

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

If a load of $W$ is applied to the string to keep it tight and $M_p$ is the mass of the scale pan, then the total load applied is $M = W + M_p$ and the tension of the string is $T = Mg$ dynes.

Hence the 2 equations become,

$$f = \frac{1}{2l}\sqrt{\frac{Mg}{m}}, \text{ for perpendicular vibration}$$

$$f = \frac{1}{l}\sqrt{\frac{Mg}{m}}, \text{ for parallel vibration}$$

## Apparatus:

- Melde's apparatus
- Thread
- Wooden clamps
- Meter scale
- Weight box and balance
- Rubber mallet etc.

## Experimental Data:

(A) Mass of the scale pan, $M_p$ = 22.26 gm

(B) Length of the sample thread, $L$ = 190 cm

Mass of the sample thread, $M$ = 0.91 gm

Thus, mass per unit length of the thread, $m = \frac{M}{L}$ = 0.0048

(C) Longitudinal position

| No. of obs. | Load on the scale pan, $W$ (gm.) | Tension, $T = Mg$ $= (W + M_p)g$ (dynes) | Distance between the pins, $G$ (cm.) | No. of loops between the pins, $N$ | Length of a segment, $l = G/N$ (cm.) | $f = \frac{1}{l}\sqrt{\frac{T}{m}}$ (Hz.) | Mean $f$ (Hz.) |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 21837.06 | 97 | 2 | 48.5 | 43.98 | 44.94 |
| 2 | 5 | 26742.06 | 104 | 2 | 52 | 45.39 | |
| 3 | 10 | 31647.06 | 113 | 2 | 56.5 | 45.44 | |

(D) Transverse position

| No. of obs. | Load on the scale pan, $W$ (gm.) | Tension, $T = Mg$ $= (W + M_p)g$ (dynes) | Distance between the pins, $G$ (cm.) | No. of loops between the pins, $N$ | Length of a segment, $l = G/N$ (cm.) | $f = \frac{1}{2l}\sqrt{\frac{T}{m}}$ (Hz.) | Mean $f$ (Hz.) |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 21837.06 | 118 | 5 | 23.6 | 45.19 | 44.79 |
| 2 | 5 | 26742.06 | 106 | 4 | 26.5 | 44.53 | |
| 3 | 10 | 31647.06 | 115 | 4 | 28.75 | 44.66 | |

## Calculation:

For Longitudinal position:

$$f = \frac{1}{l}\sqrt{\frac{T}{m}}$$

$$= \frac{1}{48.5}\sqrt{\frac{21837.06}{0.0048}}$$

$$= 43.98 \text{ Hz}$$

For Transverse position:

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

$$= \frac{1}{2 \times 23.6} \times \sqrt{\frac{21837.06}{0.0048}}$$

$$= 45.19 \text{ Hz}$$

## Result:

The frequency of the tuning fork is, $f = \frac{44.94 + 44.79}{2} = 44.865$ Hz

Physics Laboratory

**Discussions:**

Q: What is traveling wave and standing wave? How does standing wave differ from traveling waves?

A wave in which the positions of maximum and minimum amplitude travel through the medium is known as a travelling wave. Standing wave is a combination of two waves moving in opposite directions, each having the same amplitude and frequency.

Q: In this experiment why it is necessary to observe that resonance have occurred?

In this experiment, we want the frequency of the thread and tuning fork to be the same.
Resonance occurs when the two motions frequencies are same. If resonance occurs, we can say that the freq of the thread is equal to the freq of the tuning fork, hence, calculating the freq of thread will give us the freq of the tuning fork.

Q: Why the length of the string between the pulley and the scale pan should be kept short?

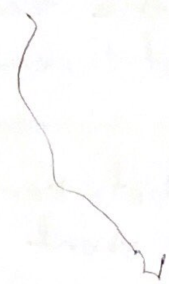
The length of the string between the pulley and the scale pan should be kept short to minimize the effects of the strings tension and ensure that the experiment is as accurate as possible. This allows for a clearer and more accurate standing wave.

Q: Why is it necessary to consider the mass of the scale pan?

In a tuning fork experiment, the mass of the scale pan is important to consider because it can affect the Tension and Frequency of the tuning fork.
When a tuning fork is struck, it vibrates at a specific freq that is determined by its mass and stiffness. The mass of the scale pan, which holds the tuning fork, can affect the stiffness of the system and alter the frequency of the tuning fork.

**Physics Laboratory**

Q: Draw the amplitude ~ frequency curve of a driven system in a low damping medium, in a high damping medium and in a medium where there is no damping?



Q: How do you know that a resonance has occurred between the fork and the string?

When a tuning fork is placed close to a string and the string is plucked, if the frequency of the plucked string matches the natural frequency of the tuning fork, a phenomenon known as resonance occurs. Resonance can be detected by observing the amplitude of the vibration of the tuning fork. If the tuning fork and the plucked string are resonating at the same freq, the amplitude of the vibration of the tuning fork will increase significantly. If resonance occurs then we will see a standing wave and the vibration will last longer.