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暨南大学本科实验报告专用纸

课程名称 Physics Experiment 成绩评定

实验项目名称 Measurement of Tuning Fork Frequency 指导教师 Zhang

实验项目编号 Ep 07 实验项目类型 实验地点

学生姓名 学号

学院 International School 系 专业 Computer Science & Technology

实验时间 2022 年 9 月 5 日 上午～ 月 日 午 温度 ℃湿度

OBJECTIVE:

1. To familiarize the student with the general properties of standing wave.
2. To measure the frequency of a tuning fork with standing waves.

THEORY:

Standing Waves on a stretched string

A simple sine ~~have~~ wave traveling along a taut string can be described by the equation $y_1 = y_m \sin 2\pi(x/\lambda - t/T)$. If the string is fixed at one end, the wave will be reflected back when it strikes that end. The reflected wave will then interfere with the original wave. The reflected wave can be described by the equation $y_2 = y_m \sin 2\pi(x/\lambda + t/T)$. Assuming the amplitudes of these waves are small enough so that the elastic limit of the string is not exceeded, the resultant waveform will be just the sum of two waves:

$$y = y_1 + y_2 = y_m \sin 2\pi(x/\lambda - t/T) + y_m \sin 2\pi(x/\lambda - t/T)$$

Using the trigonometric identity:

$$\sin A + \sin B = 2\sin\frac{A+B}{2}\cos\frac{B-A}{2}$$

the equation becomes:

$$y = 2y_m \sin(2\pi x/\lambda)\cos(2\pi t/T)$$

This equation has some interesting characteristic. At a fixed time t_0, the shape of the string is a sine wave with a maximum amplitude of $2y_m \cos(2\pi t_0/T)$. At a fixed position on the string x_0, the string is undergoing simple harmonic motion, with an amplitude $2y_m \sin(2\pi x_0/\lambda)$. Therefore, at points of the string where $= \lambda/2, \lambda, 3\lambda/2, 2\lambda$, etc., the amplitude of the oscillations will be zero.

This wavelength is called a standing wave because there is no propagation of the waveform along the string. A time exposure of the standing wave would show a pattern something like the one in Figure 1. This pattern is called the envelope of the standing wave.

Each point of the string oscillates up and down with its amplitude determined by the ~~env~~ envelope. The points of maximum amplitude are called antinodes. The points of zero amplitude are called nodes.

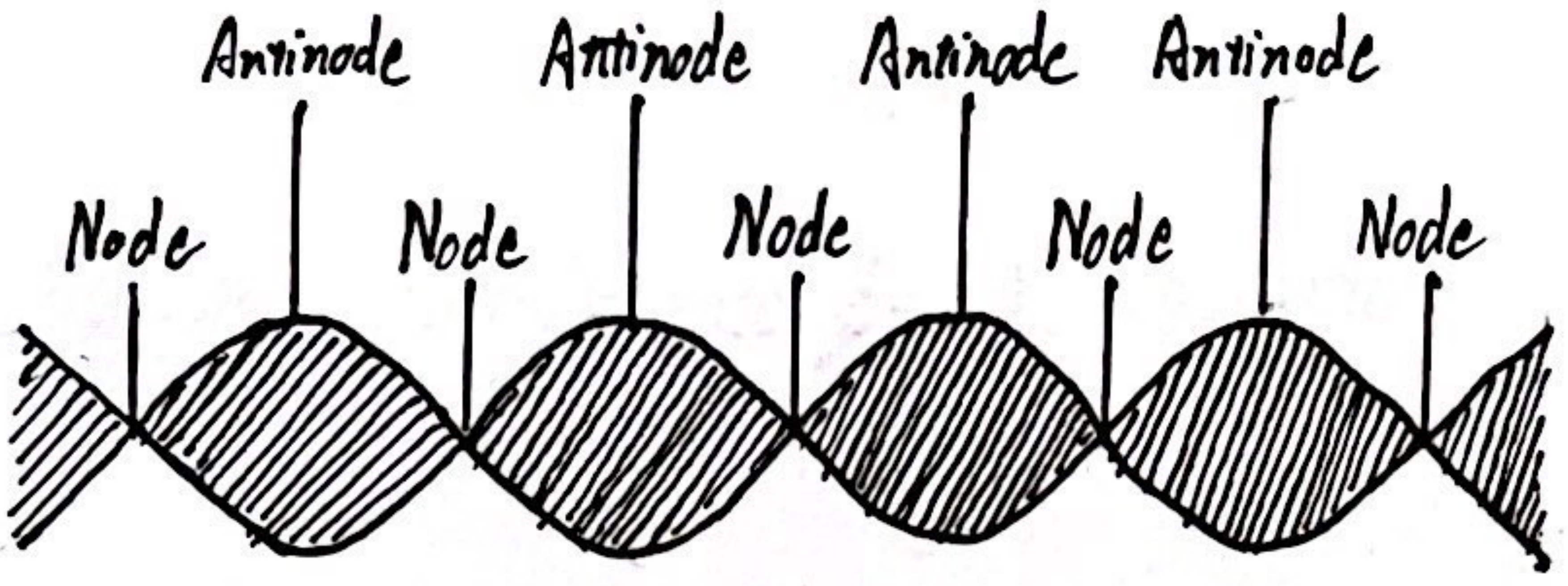

Figure 1. The Envelope of a standing wave

Reasonance

The analysis above assumes that the standing wave is formed by the superposition of an original wave and one reflected wave. In fact, if the string is fixed at both ends, each ~~w~~ wave will be reflected every time it reached either end of the string. In general, the multiply reflected waves will not all be in phase, and the amplitude of the wave pattern will be small. However, at certain frequencies of oscillation, all the reflected waves are in phase, resulting in a very high amplitude standing wave. These frequencies are called reasonant frequencies.

In general, reasonance occurs when the wavelength(L) satisfies the condition:

$$\lambda = 2l/n \ ; \quad n = 1, 2, 3, 4 \ldots \qquad (1)$$

Another way of stating this same relationship is to say that the length of the string is equal to an integral number of half wavelengths. This means that the standing wave is such that a node of the wave pattern exists ~~natna~~ naturally at each fixed end of the string.

Velocity of Wave Propagation

Assuming a perfectly flexible, perfectly elastic string, the velocity of wave propagation(V) on a stretched string depends on two variables: the mass per unit length or linear density of the string (μ) and the tension of the string (T). The relationship is given by the equation:

$$V = \sqrt{\frac{T}{\mu}} \qquad (2)$$

Frequency

The relationship among the velocity of wave propagation(V), wavelength(λ) and the ~~f~~ frequency (ν) of wave is expressed:

$$V = \lambda \nu \quad (3)$$

Using Eqs (1), (2) and (3), we obtain:

$$\nu = \left(\frac{n}{2l}\right)\sqrt{\frac{T}{\mu}} \quad (4)$$

substituting $T = Mg$ and $\mu = m/L$ into Eq(4), we obtain:

$$\nu = \left(\frac{n}{2l}\right)\sqrt{\frac{MgL}{m}} \quad (5)$$

where L = length of string, l = length of n stand waves, n = number of antinodes, m = mass of string, M = mass of balancing weight.

PROCEDURE:

(1) Measure the length and mass of the string using a meter and an electrical balance.

(2) ~~Fixed~~ Fix one end of the string to ~~the~~ either arm of the tuning fork ~~with~~ with a screw on it, make the string stride over the fixed pulley and suspend a hook at the other end of the string. Put proper weight on the hook.

(3) Adjust the fixed pulley knob so that the string is horizontal and tangent.

(4) Turn on the tuning fork power supply, adjust the screw on the side of the tuning fork until the sparks be created and the tuning fork will vibrate, at the same time, the string will vibrate, then lock the screw.

(5) Adjust the distance between the fixed pulley and the tuning fork until a steady stand wave with a larger amplitude is formed.

(6) Measure the length of ~~seve~~ several stand waves except the first one counting from the tuning fork with a meter. The length should be measured 3 times. Record the number of the stand waves, the mass of weights and the length of several stand waves in table.

(7) Change the mass of weight, then repeat procedure (5) and (6).

PRE-QUESTIONS

In the lab, which quantities need be measured? Use what device to measure them?

Answer: ① the length of string —— use straight scale

② the length of string —— use straight scale

③ the mass of string —— use digital electronic scale

DATA RECORDING AND PROCESSING

The standard frequency of the tuning fork $\nu_s = 100$ Hz (s^{-1})

Length of string L = ~~[illegible]~~ 137.10cm

Mass of string $m = 0.3697g$

Group \ Item	The length of several stand wave: l(m)	The number of stand wave: n	The mass of the weight and the hook: M(kg)	Frequency of the tuning fork: $\nu(s^{-1})$
1	0.841	6	0.02	~~[illegible]~~ 102.26
2	0.844			
3	0.843			
4	0.845			
5	0.846			
average	0.8438			
1	0.679	3	0.06	~~[illegible]~~ 103.34
2	0.675			
3	0.680			
4	0.673			
5	0.672			
average	0.6758			

Calculate the uncertainty U_ν using the follow equation:

$$\frac{U_\nu}{\nu} = \sqrt{\left(\frac{U_l}{l}\right)^2 + \frac{1}{4}\left(\frac{U_M}{M}\right)^2 + \frac{1}{4}\left(\frac{U_L}{L}\right)^2 + \frac{1}{4}\left(\frac{U_m}{m}\right)^2}$$

the result is:

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the uncertainty of l:

$$u_A = t\sqrt{\frac{\sum(l-\bar{l})^2}{n(n-1)}} = 9.807\times10^{-4}$$

$$u_B = \frac{0.20mm}{3} = 6.667\times10^{-5}$$

$$u_l = \sqrt{u_A^2 + u_B^2} = 9.8293\times10^{-4}$$

$$\frac{u_l}{l} = 1.1649\times10^{-3}$$

the uncertainty of M:

$$\frac{u_M}{M} = 3.3334\times10^{-4}$$

the uncertainty of L:

$$\frac{u_L}{L} = 0.9725\times10^{-4}$$

the uncertainty of m:

$$\frac{u_m}{m} = 0.9016\times10^{-3}$$

Hence,

$$\frac{u_v}{v} = \sqrt{\left(\frac{u_l}{l}\right)^2 + \frac{1}{4}\left(\frac{u_M}{M}\right)^2 + \frac{1}{4}\left(\frac{u_L}{L}\right)^2 + \frac{1}{4}\left(\frac{u_m}{m}\right)^2} = 1.2611\times10^{-3}$$

$$u_v = 1.2611\times10^{-3}\times v = 0.12611\,Hz$$

$v = \bar{v} \pm$,

QUESTION:

you need measure the length of ~~serveral~~ several standing wave 5 times, and every time you must move the tuning fork and adjust it until it is steady over again, then measure it, why?

Answer:

① When a standing wave is formed, the vibration place of the tuning fork is the antinode, the fixed end is the wave node, the ~~wave~~ antinode and anode is arranged alternately, and the internode distance between two adjacent waves is half wavelength, so the tuning fork must be moved in the experiment to meet the standing wave condition.

② To reduce the type A error need increasing times of measurement.