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VIBRATING STRING

OBJECTIVE

To examine the relationships between tension, mass, and the period of resonances of a string.

INTRODUCTION

Figure 1 illustrates a string stretched between two supports. The left support is the arm of the vibrator and the other is the top of the pulley. The string extends over the pulley where a weight is attached to provide tension on the string. For a vibrator oscillating with a fixed frequency, standing waves can be set up in the string when the length of string between the supports is an integer multiple of half the wavelength of the waves in the string. For the situation illustrated in Fig. 1, the string vibrates so that there are two antinodes and three nodes. Can you locate them?

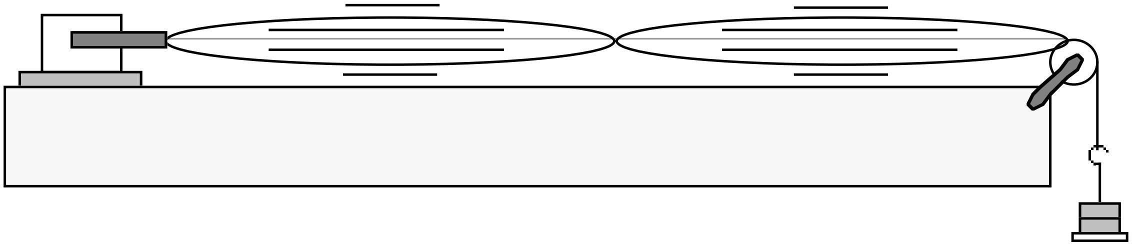

Figure 1. Vibrating string apparatus.

The speed of the wave on a string may be expressed as

$$v = \sqrt{\frac{T}{\mu}}, \tag{1}$$

where T is the tension in the string and μ is the mass per unit length of the string also known as the linear mass density. The speed of the wave is also related to the wavelength λ and frequency f through

$$v = f\lambda. \tag{2}$$

Upon combining these relationships we find that

$$f\lambda = \sqrt{\frac{T}{\mu}}. \tag{3}$$

In trying to reason what you might expect, remember that a larger tension in the string causes the restoring forces to be larger which accelerates the string faster and causes the oscillations to happen quicker (i.e., have a shorter period). By the same reasoning, a heavier string will accelerate slower and have a longer period. You will be trying to see if these things are true in this experiment.

In class you may have talked about these features in terms of the fundamental mode (lowest harmonic) of oscillation. For a given string, higher harmonics would have shorter periods or higher frequencies. Since you will be vibrating the string at a particular frequency, you cannot change the tension and continue to look at the fundamental mode. However, you can change the tension and examine higher harmonics. Each higher harmonic is related to a corresponding lower frequency fundamental mode.

ACTIVITY 1

1. **Draw the first 5 harmonics of a vibrating string**.

2. Your instructor will help you find the frequency of the tuning fork. **Record the value obtained.**

3. Measure the length of the string; then weigh it to find its mass. **Calculate the linear mass density (mass/length) from these numbers.** Give your results in SI units.

4. Clamp the vibrator and pulley to the desk. Attach the string to the central hole of the tuning fork's arm. Run the string from underneath, up through the hole and then knot it. **Measure the distance from the tuning fork to the pulley.**

ACTIVITY 2

5. Suspend the weight hanger on the string for tension and turn the vibrator on. Slowly increase the tension on the string by pushing down on the weight hanger with one finger. At some particular tension, the string will go into a single or double loop of vibration. Estimate the force you applied with your finger and place an equivalent weight on the holder.

6. Adjust the weight for maximum amplitude of the loops. Test for maximum amplitude by gently pushing down or raising up the weight hanger with a finger. Either increasing or decreasing the force should decrease the amplitude of the loops if the weight is correctly adjusted.

7. **Record the weight and the total number of loops obtained. Measure the average length of one loop, that is, the internodal distance.** *Notice that the loop nearest the vibrator is usually not well defined*.

8. **Compute the wavelength of the standing wave pattern**.

ACTIVITY 3

9. Change the tension to give at least four different numbers of loops and repeat Activity 2 for each.

10. **How many harmonics were you able to generate**? **Draw a diagram showing the situation with the highest harmonic.**

11. **Plot a graph** of T vs. λ^2. **Explain why you might expect the graph to be linear.**

ACTIVITY 4

12. Change the string to one of a different mass density and repeat Activities 2 and 3 for it.

ACTIVITY 5

13. **What conclusions can you draw from this experiment?**

Data sheet to hand in. Name ____________________

VIBRATING STRING WORKSHEET

DATA SHEET

ACTIVITY 1

Draw the first 5 harmonics of a vibrating string.

The frequency of the vibrating fork is ____________.

Measure the length of the string and its mass.

Calculate the linear mass density of the string.

Measure the length of the string from the fork to the pulley.

ACTIVITY 2 & 3

Mass added ( )	*T* ( )	Number of loops	Internodal distance (m)	Wavelength (m)

How many harmonics could you generate?

Draw a diagram.

Plot a graph of T vs. λ^2. Explain why you might expect the graph to be linear.

ACTIVITY 4

Calculate the linear mass density of the string.

Mass added ( )	***T* ( )**	**Number of loops**	**Internodal distance (m)**	**Wavelength (m)**

How many harmonics could you generate?

Draw a diagram.

Plot a graph of T vs. λ^2.

ACTIVITY 5

What conclusions can you draw from this experiment?