Lab 4:
Transverse Standing Waves

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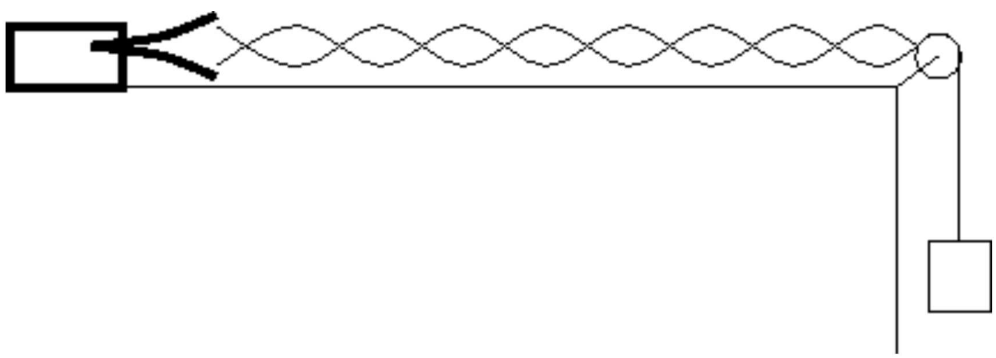
1 Introduction

Today's experiment consists of a tuning fork mounted to the lab bench, which vibrates a horizontal string that can be draped over a pulley and loaded with mass.



Adding mass to the hanger will change the tension in the string. This will change the wave speed in the string. With the frequency fixed throughout the experiment, we will generate different standing wave modes with different wavelengths. We will measure the wavelengths of the various standing waves and find the relationship between tension and wavelength.

The frequency for a standing waves in a string under tension is,

$$f = \frac{v}{\lambda} = \frac{1}{\lambda}\sqrt{\frac{T}{\mu}}$$

where f is the linear frequency of oscillation, v is the wave speed in the string, λ is the wavelength of the vibrations, T is the tension in the string, and μ is the linear mass density of the string. Explain in detail how you would determine (using tools in the lab, and without using the formula):

2 Procedure

2.1 Attach the mass hanger to the free end of the string over the pulley

Make sure that the string is parallel to the lab bench.

2.2 Add some mass to the hanger and turn on the tuning fork vibrator

Do NOT supply more than 7 volts DC to the vibrator!

2.3 Observe six or seven normal modes of vibration

The fundamental requires about 1.5 kg on the hook. The higher normal modes are obtained by decreasing the mass on the hook. *Slowly* change the amount of mass on the hook. Try and achieve the best precision you can when you measure the mass on the hanger. Eventually, the mass of the empty hook (50 g) will limit the number of normal modes that you can observe.

2.4 Normal Modes

Determine the tension in the string, the wavelength of oscillation, and the normal mode, n.

$$n = (N - 1),$$

where, N is the number of nodes. *Remember:* There is a node at each end where the string is fixed.

2.5 Repeat

Find as many different normal modes as possible. Record all data in a neat table in your lab notebook.

2.6 Find the Linear mass density (ρ)

Determine the linear mass density of the string using the method you designed in the prelab. A sample of the string along with a triple beam balance and a meter stick will be provided.

3 Analysis

- Plot the quantity m vs. λ^2 ,where m is mass, and λ is wavelength. Put λ^2 on the horizontal axis, and m on the vertical axis. Is this a straight line? (Indicate units.)
- Start with the formula from the prelab relating linear frequency, string tension, linear mass density, and wavelength. Write a formula for the linear frequency of vibration in terms of measured quantities only.
- Is the manufacturer's linear frequency f=80 Hz within your error bounds? In other words, can you verify that the tuning fork is operating as advertised?
- Identify at least two sources of statistical error.
- Identify at least two sources of systematic error.
- As usual, include Abstract, Conclusions, and other comments.