Tensions affect on the oscillatory motion of a string Theory

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I. INTRODUCTION

The basis of physics have in some way related to why oscillations do what they do. Oscillations are energy going through a certain medium in space in the form of waves. These energy waves can be captured and used for many different applications in the world that people use everyday. By figuring the components that are in these types of oscillations, many other physical systems can be analyzed in greater depth. Frequency is the main component that will be analyzed during this experiment. The definition of frequency is how many waves on an oscillator that pass through during one period of that oscillation. The speed of these waves are called the wave's velocity. The wave's velocity is determined by the amount of tension that is exerted on an object along with other parameters involved. Tension is a force that pulls on an object in different ways. In this case the object will be a string tied to pole with tension being applied on the opposite end. By using different tensions on the string, the equations that are used to calculate the frequency of a string can be confirmed by observing the oscillations being produced in the string.

II. THEORY

A string's frequency of oscillation depends on the length of the string and the velocity of the wave.

$$f_{wave} = \frac{v_{wave}}{2L} \tag{1}$$

The velocity of the wave depends on the tension and linear mass density, μ.

$$v_{wave} = \sqrt{\frac{T}{\mu}} \tag{2}$$

Combining these we see that the frequency of a wave depends on length, tension, and linear mass density, where linear mass density, μ, is mass over length.

$$f_{wave} = \frac{\sqrt{\frac{T}{m/L}}}{2L} \tag{3}$$

[redacted]

However, the string we are testing can stretch so we must separate the initial length from the stretched length.

$$f_{wave} = \frac{\sqrt{\frac{T}{m/(L_0+L)}}}{2(L_0+L)} \tag{4}$$

Where L_0 is the initial length and L is the length it has stretched. Using Hooke's Law we can find L.

$$F^s = kx \tag{5}$$

Where x is the length, L, and F^s is the tension, T. Substituting, our equation becomes,

$$f_{wave} = \frac{\sqrt{\frac{T(L_0+T/k)}{m}}}{2(L_0+T/k)} \tag{6}$$

If Equation 6 is simplified it returns,

$$f_{wave} = \sqrt{\frac{T}{4m(L_0+T/k)}} \tag{7}$$

One change that can be made is to substitute the initial linear mass density in for mass so our equation contains the variables that we will be finding in the experiment.

$$f_{wave} = \sqrt{\frac{T}{4\mu_0 L_0(L_0+T/k)}} \tag{8}$$

As we can see from Equation 8, the frequency of our wave should only depend on the tension as all other variables are constant. If the tension is increased the frequency of oscillation should increase until some unknown value where it will level off.

III. EXPERIMENT

When calculating the mass density of the string, a triple beam balance is zeroed before placing the string on the tray. Once the string was placed on the tray and the beam stopped oscillating the mass was measured. To measure the length one end of the string is placed at the end of a meter stick on a table. Ensuring that the string is flat and straight, one meter is marked and measured out. Dividing the mass by the length will provide the mass density for the string. Next, a force sensor is connected to Logger Pro and placed onto a lab stand.

After measuring voltage from the force sensor, (reference the equation) is used to convert voltage to newtons. Using this force, the spring constant is found by dividing the force by the length of string, one meter. When attempting to measure the frequency, the force sensor is placed on the pole stand. A string is then attached to a force sensor connected to Logger pro, which is used to measure the oscillations. The string is subjected to ten various tensions. Once the string is still the tension is measured. then the string is plucked and the oscillations starts. When the oscillations start the motion sensor connected to Logger Pro records the motion. Once this has been done repeat three times with different distances to create different tensions.