VIBRATING STRING Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Partners:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Course:\_\_\_\_\_\_\_\_\_\_\_\_\_ Time:\_\_\_\_\_\_\_\_\_\_\_

1. Watch the video of a vibrating string <https://www.youtube.com/watch?v=cnH2ltfW48U>

A string, stretched between two clamps, is made to oscillate in standing wave patterns as shown below. Determine the loop length and wavelength for each of the oscillations in terms of *L*, the length of the vibrating string.

|  |  |  |
| --- | --- | --- |
|  | Loop Length | Wavelength |
|  | L | 2L |
|  | L/2 | L |
|  | L/3 | (2/3) L |

1. **Experiments:**

Purpose: To investigate waves in a stretched string and determine the wave speed.

Theory: Stringed musical instruments are played by plucking or bowing a stretched string. In the first investigation a string vibrator will make the string to vibrate at a frequency of 60 Hz. The tension will be provided by a hanging mass. The vibrations will travel along the string and get reflected at the other end. The reflected waves and the incoming waves will interfere and form standing waves. By varying the tension, *T* standing waves with different number of loops can be obtained. The standing waves for two and three loops are shown below. Loop length is obtained by dividing the length of the vibrating string by the number of loops. Wavelength is twice the loop length.  
   
In terms of frequency, f and wavelength, λ the wave speed, *v* is given by:     
 

In terms of tension, *T* and strings linear density, *μ* the wave speed, *v* is given by:   
 

Linear Density: Linear density, *μ* is a property of the string which tells us whether the string is "heavy" or "light". You may know that the four violin strings are not the same. Some are thick and others are thin. The heavy strings are used for low tones and the light ones are for high tones. In this investigation you will determine *μ*, by measuring the length and mass of the string before attaching it to the string vibrator, to 3 significant figures.

Procedure:

Open the simulator, and click begin

<http://www.thephysicsaviary.com/Physics/Programs/Labs/StandingWaves/index.html>

DATA: Use SI units

1. In the first part of the experiment, you will be keep the frequency constant, and change the linear density of the string.

Set the frequency to 6.0Hz, by clicking on the circle below the frequency, and the string tension to 3 N, and click on the power. You can change the string linear density, and string tension by clicking on the vertical arrows. You can click on the power again to rest the simulation.

You can pause the oscillations, to measure the wavelength. You can also increase the amplitude of the signal by using the horizontal arrows. Measure the wavelength on the string (distance between two crests) by activating the grid, and fill the table below. If you prefer, use Excel to construct this data table.

Determine the percentage error between the two values of velocities, using *v* as a function of T and *μ* as your accepted value.



Table I:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Tension (N) | Linear density *μ (kg/m)* | Wavelength, *λ (m)* | Wave Speed, *v* (m/s) | | % Error |
| Using *f* & λ | Using *T* & *μ* |
| 3 | 0.1 | 0.88 | 5.28 | 5.48 | 3.6 |
| 3 | 0.2 | 0.6 | 3.6 | 3.87 | 6.9 |
| 3 | 0.3 | 0.5 | 3 | 3.16 | 5.1 |
| 3 | 0.4 | 0.45 | 2.7 | 2.73 | 1.1 |
| 3 | 0.5 | 0.4 | 2.4 | 2.44 | 2.02 |
| 3 | 0.6 | 0.35 | 2.1 | 2.23 | 5.8 |
| 3 | 0.7 | 0.32 | 1.92 | 2.06 | 6.7 |
| 3 | 0.8 | 0.3 | 1.8 | 1.93 | 6.7 |
| 3 | 0.9 | 0.29 | 1.74 | 1.82 | 4.2 |

Explain the origin of the percent error.

*When using the grid to measure the distance between the crests (wavelength), the reading may be off by few millimeters, and therefore create an error between the two velocities values.*

1. In the second part of the experiment you will keep the linear density and the frequency fixed, and change the tension of the string.

Use the simulation below:

<https://ophysics.com/w8.html>

For a particular tension and frequency, obtain the wavelength using the equation of the velocity. Set the frequency f= 125 Hz, and the linear density of the string to 3, and change the tension, calculate the wavelength using the velocity and frequency.

Table II:

|  |  |  |  |
| --- | --- | --- | --- |
| Tension (N) | Linear density *μ (kg/m)* | Wave speed , *v (m/s)* using T & μ | Wavelength, *λ (m)* |
| 10 | 125 | 57.74 | 0.462 |
| 20 | 125 | 81.65 | 0.654 |
| 30 | 125 | 100 | 0.8 |
| 40 | 125 | 115.47 | 0.9237 |
| 50 | 125 | 129.10 | 1.0327 |
| 60 | 125 | 141.42 | 1.131 |
| 70 | 125 | 152.75 | 1.222 |
| 80 | 125 | 163.29 | 1.306 |
| 90 | 125 | 173.21 | 1.385 |

1. How does the change in tension affects the wavelength?
2. What do you see happening to the wave when changing the tension of the string?

Conclusion: