

San Diego Mesa College

Name: _____

Physics 197 Laboratory Experiment

Date: _____

Title: Waves on a String

Group Members: _____

Objective: To investigate the relationship between the elastic and inertial properties of a material and the tension produced by a hanging mass to predict the frequency of an applied driving force by analysis of the standing wave state of the system.

Theory: The rate of energy propagation in a stretched string is described by the propagation speed:

$$v_{\text{propagation}} (m/s) = \sqrt{\frac{F_{\text{Tension}} (N)}{\mu (kg/m)}}$$

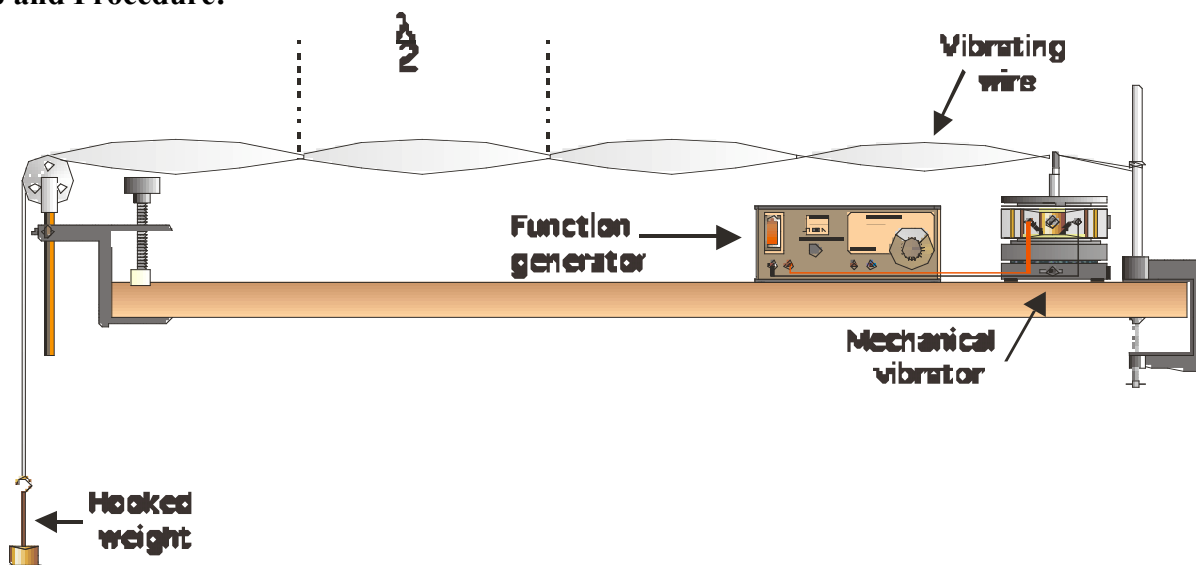
So, as the force applied to the string varies, so does the wave speed. Furthermore, the speed of any wave in any medium follows the relationship given by:

$$v_{\text{propagation}} (m/s) = \lambda(m) f(s^{-1})$$

Equipment: Mechanical Oscillator
Table Clamps
Mass Hanger
Function Generator
Strings

Pulley
Threaded Rod
Slotted Mass Set
Banana Leads
2 Meter Stick

Setup and Procedure:



Please note that each 'loop' is half of a wavelength when making your measurements

Part I:

Determination of the driving force frequency

- 1) Use the orange string. Measure the total length and the mass of the string to determine the linear mass density of the material. Record these values in the data table.
- 2) With the system set up as shown in the diagram, load the 50 g mass hanger with 950 g of mass, making a total of 1 kg.

- 3) Carefully measure the distance from the oscillator contact point to the pulley. Record this in the data table.
- 4) Set the function generator to ~ 95 Hz. This should produce 3 'loops' in the string between the oscillator and the pulley. You may need to adjust this frequency in order to obtain 'loops' of maximum amplitude.
- 5) Once the maximum amplitude condition has been met, record the frequency displayed on the function generator dial in the data table. Do not change the frequency for the remainder of part I.
- 6) Remove mass from the mass hanger until four 'loops' appear between the oscillator and the pulley. You may need to remove mass in as little as 5 g increments to obtain the maximum amplitude condition. **Do not adjust the frequency generator**
- 7) Continue to adjust the hanging mass to obtain the five, six and seven 'loop' conditions. Record the mass used for each system state in the data table. Try to be as accurate as possible.

Data:

Total Length of Orange String (m)		Total Mass of Orange String (kg)	
Oscillator Frequency (Hz)		Linear Mass Density (kg/m)	
Number of Loops	Wavelength (m)	Tension (N)	λ^2 (m ²)
3			
4			
5			
6			
7			

Show a sample calculation with units for each value in the data table in the space below:

Part II: The effects of a varying frequency on a constant tension system.

- 1) Using the orange string, find a combination of tensions and frequencies that produce a single 'loop'. Record these values in the data table.
- 2) Change the frequency of the oscillator until you achieve a two 'loop' pattern on the string.
- 3) Continue to adjust the frequency to add additional 'loops'. Try to produce as many loops as you can, but in no case should you stop taking data until you have achieved the six 'loop' condition.

Data:

Initial Tension (N)	
Number of 'Loops'	Frequency (Hz)
1	
2	
3	
4	
5	
6	

Analysis: Using your data, try to determine a relationship between the frequency of the oscillator and the number of 'loops' produced by the system. Consider the number of antinodes present in the system as a function of frequency and compare your results to the textbook equation. Comment on similarities and/or differences.

Part III: Determination of unknown linear mass density

- 1) Using the experimental procedures developed in parts I and II, devise a method to use the oscillator to measure the linear mass density of an unknown string.
- 2) Clearly explain your experimental procedure and list any data gathered then calculate the linear mass density of the unknown string.
- 3) Measure the mass and length of the unknown string and calculate the linear mass density from your physical measurements.
- 4) Finally, calculate the percent difference in the values obtained by these two methods.

Conclusion: Briefly discuss the physics involved in the experiment, summarize the data, address potential sources of error and methods to reduce or eliminate them, and state whether or not the experimental results validate the theory.