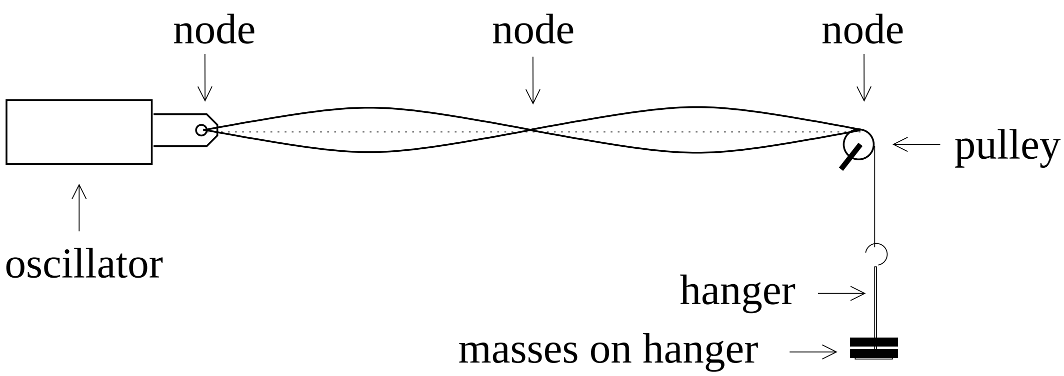
LAB SECTION: ______________________________ NAME: ______________________________

EXPERIMENT 7: SPEED OF WAVES ON A STRING

Introduction: In this lab, you will change the speed of waves on a string by stretching the string more or less tightly. More stretch, *i.e.* a tighter string, will give higher wave speeds. Using Newton's Second Law plus calculus it can be demonstrated that the wave speed squared should be proportional to the amount of force used to stretch the string; you will test this assertion. An electric oscillator will shake one end of the string back and forth (the motion of the oscillator is actually in a tiny circle) at a constant rate, *i.e.* at a constant frequency, to create waves on the string. When the waves just fit into the string length, the large amplitudes of the resulting "standing waves" will allow you to easily measure the wavelength. You will then be able to calculate the speed of the waves and test the assertion by graphing the square of the measured speed versus the amount of force used to stretch the string.



Procedure

1. One end of your string should be attached to the electric oscillator; the other end passes over a pulley and should be attached to a mass hanger. With the oscillator turned on, add masses to the hanger (thereby increasing the wave speed) until a standing wave of exactly two loops is formed on the tight string, as shown in the figure above. Add or remove small masses from the hanger until the amplitude of the standing wave is a maximum. If necessary, you may loosen the clamp holding the oscillator and slightly adjust the oscillator position for maximum amplitude. Record the hanger mass and the total added mass (both in grams) in Data Table 7.1.
2. You will be provided with a stroboscope that emits flashes of light at an adjustable frequency. Begin with the strobe set at 7200 flashes per minute (120 flashes per second) and adjust the strobe frequency until the motion of the string appears to be frozen; at that point the strobe setting is equal to the actual frequency of the oscillator. This step requires that the room lights be briefly turned off. Unfortunately, the calibration of our strobes is not precise, so we will use 120 Hz as our oscillator frequency.

3. The standing wave that you observe is produced by interference between traveling waves (the incident traveling wave and the reflected traveling wave). The points on the string which do not move are called "nodes". The distance between nodes is one-half the wavelength of traveling waves on the string. Measure the distance between two adjacent nodes in your standing wave; DO NOT use the node at the attachment to the oscillator (that point is always moving slightly). Record this measured distance (in cm) in Data Table 7.1.
4. Repeat steps one and three for standing waves having three, four, five, six, and seven loops. In each case, record the amount of hanging mass and the measured distance between two nodes in Data Table 7.1.
5. You will be given the measured mass of 10.0 m of string. Record that number at the bottom of Data Table 7.1.

Data Table 7.1 hanger mass = _____ g frequency = 120 Hz period = _____ s

# loops	node-node distance (cm)	wave length (m)	wave speed (m/s)	speed squared (m^2/s^2)	added mass (g)	total mass (g)	stretching force N
2							
3							
4							
5							
6							
7							

The mass of 10.0 m of string is _____ g.

Results

1. Fill in the remaining columns of Data Table 7.1. The time for one vibration (the period) is the reciprocal of your measured oscillator frequency. The wavelength is twice the measured distance between nodes (change from cm to m). The wave speed is the wavelength divided by the time for one vibration. The total mass is the mass of the hanger plus the mass added to the hanger. The stretching force is the amount of contact force on the string by the hanger, which is equally as strong as the weight of the hanger plus the added masses, *i.e.* the total mass **in kg** times 9.8 m/s^2. In the space below, show one example of your calculation of wave speed and one example of your calculation of the amount of stretching force.

2. Plot the amount of stetching force in newtons on the x-axis versus the square of the wave speed in m^2/s^2 on the y-axis; you should have six data points. Draw a best-fit line and calculate the slope of that line. Show your slope calculation here and on your graph, with proper units. Simplify the units as much as possible.

3. Are you able to conclude that the square of the wave speed is proportional to the amount of stretching force? Why or why not?

4. The same theory used to produce our assertion of proportionality also finds that the proportionality constant should be the number of meters in one kilogram of string. You have been given the mass of 10 m of string. Use that number to calculate the number of meters/kilogram for your string.

5. Calculate the percent error between your slope and the actual number of meters/kg for your string. Show your calculation below.

6. From your experiment, are you able to conclude that the square of the wave speed is equal to the number of meters/kilogram for the string times the amount of stretching force? Why or why not?