Vibrating Strings 2/20/2014

Physical Science 101

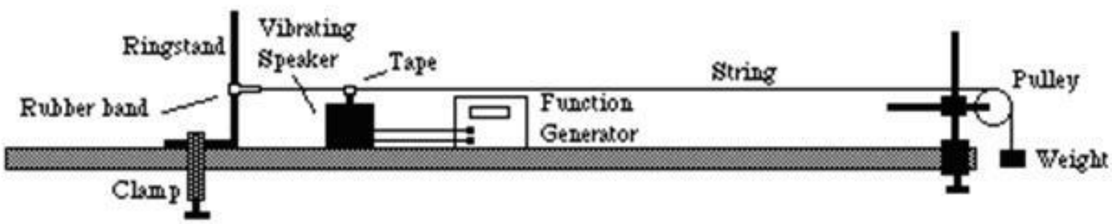
Name ________________________

Partner's Name ________________________

Objective: To learn about standing waves in vibrating strings and how tension, linear density and length effect the period of vibration.

Equipment: two types of string, vibrating speaker, pulley, weights, frequency generator, and table clamps.

Set up the equipment as shown in the figure below. When you turn on the signal generator set the amplitude to about halfway between min and max, and adjust the frequency to a frequency of less than 4 Hz. The length of the string is the distance between the speaker contact and the pulley, and the tension is the hanger weight (w=mg).



Adjust the length to be 1.00 m and the tension to about 1.0 N (i.e. put a 100 g mass as the weight so w=0.10 kg (10 m/s^2)=1.0 N. The length is the distance between where the string touches the speaker and where it touches the pulley. Use the heavier string for the first run which we will refer to as the reference run. Adjust the function generator's frequency to get the fundamental frequency of the string (i.e. the highest frequency that gives 1 vibration loop). You can check that you have the fundamental frequency correct by doubling the frequency to see if you get two loops, and if you triple the frequency from the fundamental you should get three loops for the third harmonic.

How many loops will you get when you set the generator to a frequency of 5 times the fundamental frequency (the fifth harmonic)?
Record your results for the reference run below.

Vibrating Strings 2/20/2014

Reference run:

String (heavy or light)	Tension (N)	Length (m)	Fundamental frequency Hz	2^{nd} harmonic Hz
Heavy	1.0	1.00		

Varying the Tension

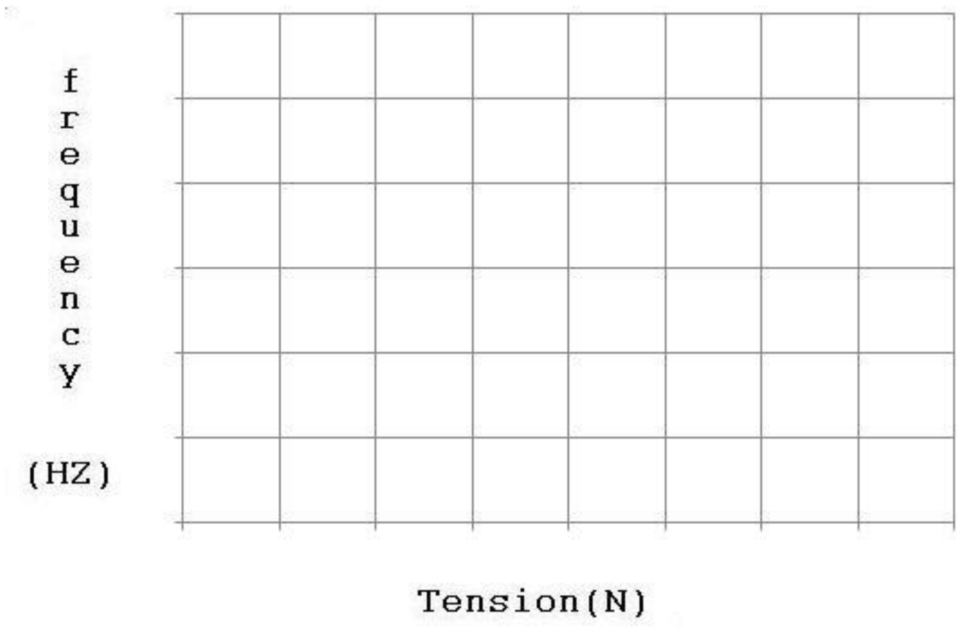
Prediction: As the tension increases the fundamental frequency **increases, decreases, or stays about the same**.

Test your prediction: Measure and record the fundamental frequency and the second harmonic for a tension that is twice as large (200 g mass on the end of the string) and half as large (50 g mass on the end of the string). The middle row of the table below is just your reference run from above.

Table 1. Increased Tension:

String (heavy or light)	Tension (N)	Length (m)	Fundamental frequency Hz	2^{nd} harmonic Hz
Heavy	0.5	1.00		
Heavy	1.0	1.00		
Heavy	2.0	1.00		

On the axes below graph the fundamental frequency on the y-axis and the tension on the x-axis for all three tensions measured. Numerically label the graph appropriately.



As the tension increases the fundamental frequency **increases, decreases, or stays about the same**.

When the tension doubles does the fundamental frequency double (this would be a linear relationship)?

When the tension quadruples does the fundamental frequency double (this would be suggestive of the frequency being related to the square root of Tension)?

Does it look like the fundamental frequency in related to the tension linearly or through the square root of tension?

Put 100 g back on the end of the string.

Varying the length

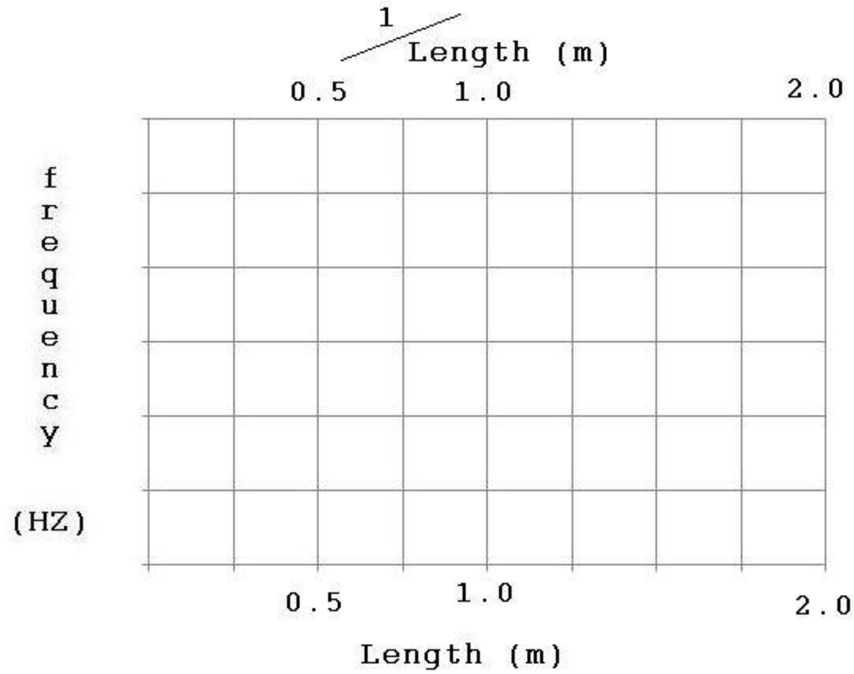
Prediction: As the length gets shorter the fundamental frequency **increases, decreases, or stays about the same**.

Test your prediction: Measure the fundamental frequency and the second harmonic for a string length that is 50 cm long (0.50 m) and 200 cm long (2.00 m). The middle row of the table below is just your reference run from the top of page 2.

Table 2. Different lengths:

String (heavy or light)	Tension (N)	Length (m)	Fundamental frequency Hz	2nd harmonic Hz
Heavy	1.0	0.50		
Heavy	1.0	1.0		
Heavy	1.0	2.00 m		

On the axes below graph the fundamental frequency on the y-axis and the length on the x-axis for all three lengths measured (the reference run is the first). Numerically label the graph appropriately.



Also on the same set of axes, graph the fundamental frequency on the y-axis and the (1/length) on the x-axis for all three lengths measured (the reference run is the first). Use either a different color or different line type. Filling in the table below should help. If you used different lengths, simply change the table values. Record frequency values from Table 2 below.

Length (m)	1/length (1/m)	Fundamental freq (Hz)
0.50	2.00	
1.00	1.00	
2.00	0.5	

As the string becomes shorter the fundamental frequency **increases, decreases, or stays about the same**.

Does doubling the length double the fundamental frequency? Yes or No

Does halving the length double the fundamental frequency? Yes or No

Doe the frequency depend on length or (1/length) in a linear way?

Set the length back to 1.00 m. (you should also have 100 g mass on the end of the string providing 1.0 N of Tension)

Varying the string density (mass per meter)

Prediction: As the density gets smaller the fundamental frequency **increases, decreases, or stays about the same**.

Test your prediction: Measure the fundamental frequency and the second harmonic for the lighter string.

Lighter string:

String (heavy or light)	Tension (N)	Length (m)	Fundamental frequency Hz	2^{nd} harmonic Hz
Light	1.0	1.00		

When the string density becomes smaller (lighter string) the fundamental frequency **increases, decreases, or stays about the same**.

What is the ratio of the fundamental frequency for the lighter string run compared to the reference run?

$$\text{Ratio} = \frac{\text{Frequency}_{\text{light}}}{\text{Frequency}_{\text{Heavy}}} = \frac{\qquad}{\qquad} =$$

Measure the mass of the heavy string and its total length so you can calculate its density in grams/meter.

$$\text{Density}_{\text{Heavy}} = {}^{\text{mass}}/_{\text{length}} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

Measure the mass of the lighter string and its length so you can calculate its density

$$\text{Density}_{\text{Light}} = {}^{\text{mass}}/_{\text{length}} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

What is the ratio of the densities ? _____________

$$\text{Ratio} = \frac{Density_{\text{Heavy}}}{Density_{\text{Light}}} = \underline{\hspace{3cm}} =$$

What number do you get when you take the square root of the ratio of densities?

$$\sqrt{\text{Ratio}} = \sqrt{\frac{Density_{\text{Heavy}}}{Density_{\text{Light}}}} =$$

Do either of these two ratios agree with the ratio of the fundamental frequencies? If so which one?

1)The fundamental frequency of a violin string is 440 hertz. The frequency of its second harmonic is
A)220 hertz. B) 440 hertz. C)880 hertz. D) none of these.

2)A string vibrating at its third harmonic frequency has a node at each end and, between these.
A)no additional nodes B)1 additional node C)2 additional nodes D)3 additional nodes E)4 additional nodes

3)A piano tuner knows that a key on the piano is tuned to the frequency of his tuning fork when he strikes them at the same time and the number of beats he hears each second is
A)0 B) 1 C) 2 D) 3 E) 4

In the space below draw a string vibrating in its fourth harmonic.

How many nodes are there?

How many antinodes?

How many full wavelengths fit between the ends of the string?