RESONANCE/STANDING WAVES ON STRING

Apparatus: String vibrator, string, 2 table clamps, mounted pulley, meter stick, slotted weights, weight hanger, and balance.

Standing waves on or within any material are produced by the interference of two wave trains of the same wavelength, speed and amplitude traveling in opposite directions. For example, this may be accomplished on a string by setting it in motion using a vibrating mechanism at one end and allowing the waves to travel the length of the string and then reflect back along the string from a fixed node.

A stretched string can have many modes of vibration. It can vibrate as a single segment (half wavelength), two segments (full wavelength, one half moving upward while the second half moves downward) or any integer multiple of half wavelength segments. The number of segments is dependent on the speed, v that the wave has as it travels along the string as well as dependent on the length, L of the string and the frequency of vibration, f of the vibrating mechanism. The wavelength, λ of the standing wave on the string is twice the length of one of the string segments. If the string is vibrating as a single segment, the wavelength is twice the length of string. If the string is vibrating in two segments, the wavelength of the wave is equal to the string length. The string length is the section of string between vibrator and top of the pulley wheel.

When standing waves are produced on the string, the frequency of vibration of the vibrator and the frequency of vibration of that mode of vibration of the string are the same. There also exists a relationship between the speed of the wave on the string, the frequency of the wave on the string and the wavelength of the wave on the string. This relation is given as

$$v = f * \lambda \qquad (1)$$

where v is the speed of the wave in meters/sec, f is the frequency of the vibrator in cycles/sec or hertz, and λ is the wavelength in meters (length of one cycle, measured peak-to-peak, trough-to-trough, or across three consecutive nodes.) You will use this relationship to determine the speed of the waves and then try to obtain a relationship between the speed of the wave and the amount of weight suspended from the string causing a tension in the string.

Procedure:

1. Measure and record the length of string between the vibrator and the top of the pulley. This will be the length of string in vibration and will allow you to determine the wavelength of the wave traveling on the string when a standing wave pattern is set up.

2. Start the vibrator. Grasp the free end of the string hanging over the pulley and pull downward with increasing force. As you do you should see the string begin to vibrate in many segments. Increasing the force on the string reduces the number of segments in the standing wave pattern. A standing wave is one where there are fixed

places where the string does not vibrate (nodes) and other places where there is a large vibration (peaks). The points of no vibration are called nodes and the place of maximum vibration is called an anti-node. A wavelength is twice the distance between two adjacent nodes, which is the total length of two consecutive segments.

3. Replace the pull of your hand with the weight hanger including enough total weight to get the string to vibrate in 7 segments (approx. 55 grams including the hanger). Record the wavelength and the tension in the string (tension = weight hanging from the string = mass in kilograms times acceleration of gravity). Calculate the speed of the wave for this wavelength. The frequency of the vibrator will always be 120 cycles/second.

4. Repeat step 3 for 6, 5, and 4 segments (approx. 75, 105, and 170 grams respectively.) For each one of the weights, record the wavelength (meters/cycle), the tension in the string and calculate the speed of the wave.

5. Make a graphical plot of the wave speed versus the tension in the string. Draw a smooth curve through your data (or have Excel add a trend line), since the data is subject to experimental error and the data points represent only an approximate value.

6. If the plot from step 5 is not a straight line, it means the speed does not vary directly with the tension. Try making a plot of speed versus the square of the tension. If that doesn't give a straight line, try plotting the square of the speed versus the tension. If that doesn't work, consult your instructor.

1. Length of string in vibration: ________________ meters

Number of Segments	Wavelength	Tension	Speed	Tension Squared	Speed Squared
7					
6					
5					
4					

Which of the graphs provided you with a straight line? The plot of _________________

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