STANDING WAVES IN STRINGS

Physics 102

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OBJECTIVE: To make an experimental study of standing waves in a string.

MATERIALS:

* An Electromagnetic standing String Vibrator
* Approximately two meters of light string
* A set of hanging weights
* A meter stick
* A pulley
* Table clamp

BACKROUND: As a vibration propagates across a medium it exhibits a wave pattern. The amplitude of the wave is the maximum displacement of the particles from their equilibrium positions. Intensity of a wave is determined by its amplitude. Frequency is how often a wave propagates over a certain time unit. The velocity of the wave can be determined by:

$$V=n\*λ$$

Where n is the number of waves generated per time unit and λ is the wavelength. A vibration traveling through a cord creates a transverse wave that travels to the end of the cord where it is then reflected back in the opposite direction. If a source continues to produce waves in this instance there will be transverse waves traveling in opposite directions across the cord. A standing wave is produced under the right combination of frequency, velocity, amplitude and wavelength. A standing wave has points where both of the opposite traveling waves reach equilibrium, this point is called a node. The number of nodes in the system is related to the force or tension on the cord. This relationship is used to create an equation to find the number of waves generated in a second (n).

$$n=\frac{1}{2\*l}\*\sqrt{\frac{F}{m}}$$

Where l is the distance from one node to the next, F is the tension force on the cord, and m is the linear density of the cord (mass per unit length).

PROCEDURE: A length of string was cut to two meters and weighed to determine its mass. The linear density of the cord was determined. One end of the sting was tied to the String Vibrator the other end was tied into a small loop. The pulley was clamped to the end of a table and set so that it was level with the String vibrator. The end of the string with the loop was hung over the pulley so that it was dangling off of the table.

The Vibrator was turned on and hanging masses were hung from the loop until there was only one visible loop with two nodes in the portion of the string on the tabletop. The length from node to node was measured and the amount of mass hanging on the loop was recorded. This process was repeated when mass was removed to create two loops, three loops, four loops, and five loops in the string. Frequencies were calculated using the measurements for each loop for each trial. The average frequency was calculated for each trial.

DATA:

|  |  |  |  |
| --- | --- | --- | --- |
| String Mass | String Length | String density | Acceleration due to Gravity |
| kg | m | kg/m | m/s2 |
| 0.0007 | 2 | 0.00035 | 9.81 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| # of loops | Mass | Legnth of loop | Tension | Frequency | Average Frequency |
|   | kg | m | N | Hz | Hz |
| 1 | 0.5 | 1 | 4.905 | 59.19097422 | 59.19097422 |
|   |  |  |  |   |   |
|   |  |  |  |   |   |
|   |  |  |  |   |   |
|   |  |  |  |   |   |
| 2 | 0.105 | 0.501 | 1.03005 | 54.14114168 | 54.24964096 |
|   | 0.105 | 0.499 | 1.03005 | 54.35814024 |   |
|   |  |  |  |   |   |
|   |  |  |  |   |   |
|   |   |   |   |   |   |
| 3 | 0.05 | 0.337 | 0.4905 | 55.5425209 | 56.16106415 |
|   | 0.05 | 0.335 | 0.4905 | 55.87411804 |   |
|   | 0.05 | 0.328 | 0.4905 | 57.06655349 |   |
|   |  |  |  |   |   |
|   |   |   |   |   |   |
| 4 | 0.022 | 0.237 | 0.21582 | 52.38820041 | 50.44426301 |
|   | 0.022 | 0.307 | 0.21582 | 40.44300814 |   |
|   | 0.022 | 0.232 | 0.21582 | 53.51725646 |   |
|   | 0.022 | 0.224 | 0.21582 | 55.42858704 |   |
|   |   |   |   |   |   |
| 5 | 0.0185 | 0.212 | 0.181485 | 53.7057133 | 57.02952289 |
|   | 0.0185 | 0.203 | 0.181485 | 56.08675478 |   |
|   | 0.0185 | 0.199 | 0.181485 | 57.21412673 |   |
|   | 0.0185 | 0.2 | 0.181485 | 56.9280561 |   |
|   | 0.0185 | 0.186 | 0.181485 | 61.21296355 |   |

Sample Calculation: 1 Loop

$$n=\frac{1}{2\*1 meter}\*\sqrt{\frac{0.5 Kg\*9.8\frac{m}{s^{2}}}{0.00035\frac{Kg}{m}}}=59.19 Hz$$

RESULTS:

The average frequency when there was 1 Loop = 59.19 Hz, The mass on the string was 0.500 Kg. the tension force was 4.905 N.

The average frequency when there was 2 Loops = 54.25 Hz, The mass on the string was 0.105 Kg. the tension force was 1.300 N.

The average frequency when there was 3 Loops = 56.16 Hz, The mass on the string was 0.050 Kg. the tension force was 0.4905 N.

The average frequency when there was 4 Loops = 50.44 Hz, The mass on the string was 0.022 Kg. the tension force was 0.2158 N.

The average frequency when there was 5 Loops = 57.03 Hz, The mass on the string was 0.0185 Kg. the tension force was 0.1814 N.

DISSCUSSION: There is a node located at the string vibrator because the waves originate from that location and after being reflected off of the other side of the string they make their way back to that same location. The loops created in the experiment represented a standing wave. They could not continually travel in the same direction therefore they “bounced” between both sides of the setup.

CONCLUSION: The string is a medium through which a wave can propagate and tension limits the amount of freedom a wave has when traveling through this medium. In this situation a standing wave was produced and able to be changed to different wavelengths by adjusting the tension on the string.