Vibrating Spring Lab
Teacher's Guide

Topic:

Waves

The following information is provided to the student:

> **Question:**
> What is the mathematical relationship between the spacing distance between adjacent nodes in a longitudinal standing wave pattern and the frequency of the vibrations which are causing the patterns?
>
> **Purpose:**
> To determine the mathematical relationship between the spacing distance between adjacent nodes in a longitudinal standing wave pattern and the frequency of the vibrations which are causing the patterns.
>
> A complete lab write-up includes a Title, a Purpose, a Data section, a Conclusion, and a Discussion of Results. The Data should organize the collected data into a table with a row-column format. Once collected, the Data should be analyzed in an effort to find a mathematical pattern and ultimately an equation relating the two measured quantities. This analysis should be documented in the lab notebook. Cross-outs, wrong turns, scribble-overs and other signs of investigative efforts should be evident in your lab notebook. And of course, a data plot and linear or power regression analysis is also permitted. The Conclusion should include a verbal statement and an equation which seems to fit the data. The Discussion of Results should explain the significance of the equation; the meaning of nodal spacing distance should be described and related to wavelength of the standing wave pattern. The equation should be related to other equations learned in the Waves section of the course; the meaning of any constants in the equation should be explained.

Materials Required:

Digital function generator; wave driver; spring; meter stick; lab poles and clamps; 1-kg hooked mass.

Description of Procedure:

A wave driver is mounted on a lab pole at an elevated position above the lab table. A spring is attached to the amplifier and stretched straight downward and hooked onto a 1-kg hooked mass at rest on the table. The output of a digital function generator is connected to the wave driver. When turned on, a longitudinal standing wave pattern can be established in the spring. Altering the frequency output changes the harmonic number and the wavelength. The frequency is adjusted to a low frequency so as to establish a clearly visible standing wave pattern with nodal and antinodal positions. (It could correspond to the fourth or the fifth or the sixth harmonic; it does not need to be the first or the second.) The distance between adjacent nodal positions is measured. The frequency is slowly adjusted upward until the next harmonic is established. The distance between adjacent nodal positions is measured for this new harmonic. The process is continued several more times in order to collect as much data as possible. Students inspect the data, plot it, analyze it and attempt to establish the relationship between the two quantities.

Alternative Materials and Procedure:

The Laboratory

Alternative materials and procedures are not recommended.

Safety Concern:

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

Suggestions, Precautions, Notes:

1. Though costly, mechanical wave drivers and digital function generators are available from many science supply houses. For instance, Pasco Scientific offers the following models: PI-8127 Function Generator and SF-9324 Wave Driver.
2. Given the cost and sophistication of the equipment, this lab makes for an ideal demonstration lab. Data can be collected quite quickly (~10-15 minutes) when demonstrated by the teacher. The rigor of the lab lies in the actual analysis of the data. This task is best left for the students.
3. To demonstrate the true nature of a node and an antinode, place a note card in between two adjacent coils of the spring at both a nodal and an antinodal position.   Silence occurs when placed at the nodal position and the sound of *chattering teeth* is heard when placed at the antinodal position.
4. The spatial distance between adjacent nodal positions is equivalent to one-half the wavelength for the specific standing wave pattern. This distance would be expected to be inversely related to the frequency of the standing wave pattern.

Auxiliary Materials:

None

Scoring Rubric:

W6.	Vibrating Spring Lab	Score
___	Included, labeled and organized all parts of the lab report.	
___	Data section includes nodal spacing distance and frequency data for the spring; organized in a table with column headings and units indicated. An analysis of the data is clearly evident; this analysis may be in the form of a graph (with power regression or linear regression statistics clearly reported), a trial-and-error number-crunching routine (multiplying, dividing, raising to a power, etc.)	____/____
___	Conclusion answers the *question* posed in the Purpose. The mathematical equation determined by the analysis is reported; symbols in the equation are defined. The relationship between the two variables is described in words - e.g., direct, inverse, linear, power, etc.	
___	Discussion of Results explains the meaning of the equation; the equation is related to the wave equation; the distance between adjacent nodes is related to the wavelength; the meaning of any constant numerical values within the equation are discussed. The discussion is complete, thorough, and reveals both effort and understanding.	

Connections to The Physics Classroom Tutorial:

The following readings are a suitable accompaniment to this lab:

http://www.physicsclassroom.com/Class/waves/u10l4b.cfm

http://www.physicsclassroom.com/Class/waves/u10l4c.cfm

The Laboratory

Connections to Minds on Physics Internet Modules:

Sublevel 7 of the Waves module is a suitable accompaniment to this lab: