

## Harmonic Frequencies Lab

### Teacher's Guide

**Topic:**

Waves

**The following information is provided to the student:**

**Question:**

How can the individual harmonic frequencies of the standing wave patterns for a string be mathematically related?

**Purpose:**

To determine the mathematical relationship between the various harmonic frequencies for the standing wave patterns of a string and to express the relationship in the form of a single equation.

A complete lab write-up includes a Title, a Purpose, a Data section, a Conclusion and a Discussion of Results. The Data section includes a table with column headings: harmonic number, standing wave pattern, and frequency. The Conclusion section includes a couple of sentences and an equation which responds to the purpose of the lab; symbols used within the equation are clearly defined. The Discussion of Results should explain how the collected data are consistent with the equation written in the Conclusion. Specific rows of the table should be referenced and discussed in an effort to show how the equation fits the data.

**Materials Required:**

Digital function generator; wave driver; wire; lab poles and clamps; pulley; 500-g hooked mass.

**Description of Procedure:**

An approximately 1-meter length of steel wire is secured to a clamp on a lab pole at one end of the lab table. A 500-g hooked mass is secured to the other end of the wire and draped over a pulley at the opposite end of the table. A *wave machine* is set up by connecting the output of a digital function generator to a wave driver. The wave driver is attached to the wire so as to vibrate it up and down. The frequency of the generator is adjusted in order to force the wire to vibrate with its second harmonic pattern. The frequency and harmonic number is recorded. The frequency is slowly increased until the third harmonic standing wave pattern is established in the wire; the new frequency and harmonic number is recorded. Measurements are carefully repeated for a variety of harmonics in order to accumulate an extensive data set. The data are analyzed by inspection or graphically in order to determine a mathematical equation which relates the frequencies of all the harmonics.

**Alternative Materials and Procedure:**

Strong string can be used in place of steel wire. If a digital function generator and a wave driver are not available, then an online animation can be used to target the same relationship. An effective animation for replacing the need for a digital function generator and a wave driver is found at:

<http://www.ngsir.netfirms.com/englishhtm/StatWave.htm>

**Safety Concern:**

## The Laboratory

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. Students with long hair should be careful around a vibrating wire. Entrapment of the hair in the vibrating wire is a common hazard and most often results in a very bad hair day.

### 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 might be more suited as a 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. Depending on the wire chosen for this lab, a 500-g mass may not be the best mass for creating tension in the wire. Experiment with various masses in advance of the lab.
4. Warn students about the hazard of draping their hair into the vibrating wire and becoming entangled.

### Auxiliary Materials:

None

### Scoring Rubric:

<b>W8. Harmonic Frequencies Lab</b>	<b>Score</b>
____ Included, labeled and organized all parts of the lab report. ____ Data section includes a table with harmonic number, wave pattern, and frequency. Stated column headings and units. Data is reasonably accurate. ____ Conclusion includes a couple of well-written sentences to introduce the mathematical equation which relates the various harmonic frequencies. Meaning of symbols within the equation are defined. ____ Discussion of Results explains the logical connection between the collected data and the stated equation. Discusses specific results to show how the equation fits the data.	____/____

### 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>

<http://www.physicsclassroom.com/Class/waves/u10l4d.cfm>

### Connections to Minds on Physics Internet Modules:

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

<http://www.physicsclassroom.com/mop/module.cfm>