# Guitar String Lab
### Teacher's Guide

**Topic:**

Sound and Music

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

> **Question:**
> How does doubling, tripling and quadrupling the length of a guitar string effect the collection of harmonic frequencies at which it naturally vibrates and the speed at which waves travel within it?
>
> **Purpose:**
> To determine how a doubling, tripling and quadrupling of the length of a string effects the collection of harmonic frequencies at which it naturally vibrates and the speed at which waves travel within in it.
>
> A complete lab write-up includes a Title, a Purpose, a Data section, a Conclusion and a Discussion of Results. The Data section should include the provided table with all data collected. The Conclusion section should describe the effect of doubling, tripling and quadrupling the length upon the frequency of the waves and upon the speed of the waves. The Discussion of Results section should provide the logical support for the conclusion statements which are made; specific trials should be referenced as supporting evidence.

**Materials Required:**

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

**Description of Procedure:**

An approximately 1.5-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 at a distance of 1.20 m from where the wire is attached to the lab pole. 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 and the fourth harmonic standing wave patterns are established in the wire. The frequencies of these harmonics are recorded. Measurements are carefully repeated for the second, third and fourth harmonics for vibrating wire lengths of 0.90 m, 0.60 m, and 0.30 m from the pole. The data are then analyzed in order to determine the answer to the question raised in the Purpose of the lab.

**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 accomplish a similar Purpose. 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:**

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

**The Laboratory**

safe as possible.  Student *horseplay* and off-task behaviors should not be tolerated.  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. 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.
3. Warn students about the hazard of draping their hair into the vibrating wire and becoming entangled.  There's much better ways to get all wired up.
4. This lab will take a period or more to manipulate equipment and to collect reasonable data.  If students have experimented with the creation of standing wave patterns in other labs, then this lab could serve as an effective assessment of students' ability conduct a controlled investigation of the effect and non-effect of a variable (wire length) upon other quantities (frequency and speed).  After explaining the Purpose clearly, it might be wise to sit back, stay out of the students' way and observe to see if they have acquired such a skill.

**Auxiliary Materials:**

The following page is provided to the student for completion and inclusion in the Data section of their lab notebook.

| Harmonic Number | Length (m) | Wavelength (m) | Frequency (Hz) | Speed (m/s) |
|---|---|---|---|---|
| 2 | | | | |
| 2 | | | | |
| 2 | | | | |
| 2 | | | | |

| Harmonic Number | Length (m) | Wavelength (m) | Frequency (Hz) | Speed (m/s) |
|---|---|---|---|---|
| 3 | | | | |
| 3 | | | | |
| 3 | | | | |
| 3 | | | | |

| Harmonic Number | Length (m) | Wavelength (m) | Frequency (Hz) | Speed (m/s) |
|---|---|---|---|---|
| 4 | | | | |
| 4 | | | | |
| 4 | | | | |

**The Laboratory**

| | | | | |
|---|---|---|---|---|
| 4 | | | | |

In the space below, clearly show and label your work for the wavelength and the speed calculations for the two tables above.

**Scoring Rubric:**

| **S6.** | **Guitar String Lab** | **Score** |
|---|---|---|
| ____ | Included, labeled and organized all parts of the lab report. | |
| ____ | Data section includes provided table; table is complete. Work for calculations are clearly shown and labeled. Data is reasonably accurate. | ____/____ |
| ____ | Conclusion clearly and thoroughly describes the effect (or non-effect) that doubling, tripling and quadrupling the string length has upon the frequency and the speed. Writing is organized, clear and responds to *the question*. The conclusions are accurate and consistent with the data. | |
| ____ | Discussion of Results provides the logical support for the Conclusion; specific trials of data are cited as evidence in support of each statement made in the Conclusion section. | |

**Connections to The Physics Classroom Tutorial:**

The following readings are a suitable accompaniment to this lab:

http://www.physicsclassroom.com/Class/sound/u11l4c.cfm

http://www.physicsclassroom.com/Class/sound/u11l4d.cfm

http://www.physicsclassroom.com/Class/sound/u11l5c.cfm

**Connections to Minds on Physics Internet Modules:**

Sublevels 6 an 7 of the Sound and Music module are suitable accompaniments to this lab:

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