

**2008  
Winning Lesson Plan  
from Cranston,  
Rhode Island**

*Harp Lab*

by Ann Walkup  
Cranston High School East

Subject: CP and Honors  
Physics

Grade Level: 11 and 12

Duration: Extended Task,  
Four Days

## Overview and Purpose

Students must be able to do the following:

- Measure and record precise and accurate data in an organized fashion.
- Use Excel to plot data graphically.
- Recognize and evaluate trends represented in graphed data.
- Work together both within their group and with other groups to acquire and evaluate all appropriate data.
- Interpret graphed trends into written statements.
- Connect trends with physical features of the harp and form meaningful relationships.

Students will create a lab report and excel spreadsheet to discuss and analyze the wavelength, frequency, tension, and linear density of a sampling of the strings on the harp.

This lab activity requires students to record measurements and observations from an actual instrument in order to quantify the importance of its physical features. It actively brings physics to life for the students.

This unit focuses on mechanical waves and sound. Students will already have been instructed regarding wave phenomena and properties, particularly on wave behavior in strings or similar solids. They will also have learned about the relationships between the linear density of a material, the tension in the material, and at what frequency it will vibrate.

In performing this lab, they will discover how these concepts are applied to a musical instrument, how form and function are related, and demonstrate their ability to calculate wavelength, frequency, tension, and linear density with regard to the harp strings. They should also be able to organize this data on a graph to see how these properties change from string to string. In graphing this data, they should also be able to relate an increase in tension at string C4 to a crack in the sound board at the same location. Students will be working together on different tasks to create a whole picture of what is going on.

This activity is a culminating event for the unit in which students can demonstrate all of the skills they have learned about mechanical wave analysis. Students will have to evaluate the data gathered by themselves and others for accuracy before the final project is completed.

**2008  
Winning Lesson Plan  
from Cranston,  
Rhode Island**

*Harp Lab*

by Ann Walkup  
Cranston High School East

Subject: CP and Honors  
Physics

Grade Level: 11 and 12

Duration: Extended Task,  
Four Days

## Educational Standards Addressed

### Applied Learning Standards

- A1 – Problem solving
- A2 – Communication tools and techniques
- A3 – Information tools and techniques
- A4 – Learning and self management tools and techniques

### Content Standards

- Science as Inquiry – A 1: Abilities necessary to do scientific Inquiry
- Science as Inquiry – A 2: Understanding scientific inquiry
- Developing Student Understanding – B 4 a: Motion and Forces,  $F = ma$
- Developing Student Understanding – B 6 a: Interactions of Energy and Matter, wave motion
- Science and Technology – E 1: Abilities of technological design
- Science and Technology – E 1: Understandings about science and technology

### GSEs

#### *Physical Science GSEs*

- GSE PS2 – Energy is necessary for change to occur in matter. Energy can be stored, transferred, and transformed, but can not be destroyed.
- GSE PS3 – The motion of an object is affected by forces.

#### *Written and Oral GSEs*

- W1 – Applying understanding of sentences, paragraphs, and text structures
- W6 – Reports
- W7 – Procedures
- W8 – Persuasive writing
- W9 – Applying rules of grammar usage and mechanics

#### *Math GSEs*

- (F&A)–10–3 Demonstrates conceptual understanding of algebraic expressions.
- M(DSP)–12–1 Interprets a given representation

**2008  
Winning Lesson Plan  
from Cranston,  
Rhode Island**

*Harp Lab*

by Ann Walkup  
Cranston High School East

Subject: CP and Honors  
Physics  
Grade Level: 11 and 12  
Duration: Extended Task,  
Four Days

## Educational Standards Addressed (Cont'd)

### “New Standards”

- S1 – Physical Sciences Concepts
- S4 – Scientific Connections and Applications
- S5 – Scientific Thinking
- S6 – Scientific Tools and Technologies
- S7 – Scientific Communication
- S8 – Scientific Investigation
- A1 – Problem Solving
- A3 – Information Tools and Techniques
- A5 – Tools and Techniques for Working With Others

### School-Wide Expectations

Academic expectation 2 – The CHSE graduate demonstrates effective employment of the problem solving process.

Academic expectation 4 – The CHSE graduate is able to understand, explain, and apply concepts and skills of mathematics, science, and technology to make informed decisions and recognize the connections to the real world.

**2008  
Winning Lesson Plan  
from Cranston,  
Rhode Island**

*Harp Lab*

by Ann Walkup  
Cranston High School East

Subject: CP and Honors  
Physics

Grade Level: 11 and 12

Duration: Extended Task,  
Four Days

## Objectives

Students must be able to recognize how function follows form and how physical properties of the harp dictate how the instrument behaves. Students must be able to measure and analyze the wavelength, frequency, tension, and linear density of the strings and relate them to the overall structure of the harp.

## Materials

1. 36-string Celtic lever harp, nylon strung, rosewood frame, made in Pakistan
2. Meter sticks
3. Electronic balance
4. Fine electronic balance
5. Tweezers
6. Sample string remnants
7. Electronic tuner with frequency readout
8. Computer with Excel and internet access for data recording and dissemination
9. Calculator (optional)

**2008  
Winning Lesson Plan  
from Cranston,  
Rhode Island**

*Harp Lab*

by Ann Walkup  
Cranston High School East

Subject: CP and Honors  
Physics

Grade Level: 11 and 12

Duration: Extended Task,  
Four Days

## Procedures

Students will be broken up into groups to gather different pieces of data. Once your group has gathered and double-checked your data, upload it to the class Excel sheet to be shared with the other groups.

### The Harp: Wavelength

- Measure the length of the F and C strings.
- Note that the Fs are blue and the Cs are red.
- With this information, you can determine the wavelength of the particular note produced by the string.

### The Scales: Mass Per Unit Length

- Determine the mass of each string sample using the appropriate scale. Also measure the total length of the string sample.
- You now can determine the mass per unit length of each string.

### Frequency Information Sheet: Frequency

- C4 is middle C. F3 is the F just above it, noted on the sheet
- Using the frequency information given on the data sheet, determine the frequency of each F and C string.

### Final Calculations: Velocity and Tension

- Using the information you have gathered, determine the velocity and tension of each string.

### Graphs: Make Graphs of the Following to Illustrate the Trends You Notice

- Frequency vs. String length
- Wavelength vs. String length
- Velocity vs. String length
- Tension vs. String length
- Linear density vs. String length
- Be sure to include proper units and labels

### Some Points to Consider in Your Evaluation Include

- Are any mathematical trends apparent?
- Where is there the most tension – the neck, the column, or in the middle? Why might this be?
- Why are there different strings thicknesses? How could this be important when considering tension?
- Are there any structural features that would affect the physical factors being analyzed?

## Extensions Beyond the Classroom

### Activities Outside of the Classroom That Reinforce the Lesson Plan

Music has been a very important cultural artifact for thousands of years. Most students will readily agree that the music they listen to is important to them. Knowing and understanding how the music is created adds a new level of appreciation for the musicians and their instruments.

A significant number of students who take physics at Cranston High School East are musicians themselves. Their abilities range from still learning an instrument to casually playing guitar to earning awards in school ensembles. These students in particular appreciate this lesson and I usually hear positive comments from the music staff regarding renewed interest in music theory in the weeks following this experiment.

**2008  
Winning Lesson Plan  
from Cranston,  
Rhode Island**

*Harp Lab*

by Ann Walkup  
Cranston High School East

Subject: CP and Honors  
Physics

Grade Level: 11 and 12

Duration: Extended Task,  
Four Days