Activity 2

Sounds in Strings

GOALS
In this activity you will:
• Observe the effect of string length and tension upon pitch produced.
• Control the variables of tension and length.
• Summarize experimental results.
• Calculate wavelength of a standing wave.
• Organize data in a table.

What Do You Think?
When the ancient Greeks made stringed musical instruments, they discovered that cutting the length of the string by half or two-thirds produced other pleasing sounds.

• How do guitarists or violinists today make different sounds?

Record your ideas about this question in your Active Physics log. Be prepared to discuss your responses with your small group and with your class.

For You To Do
1. Carefully mount a pulley over one end of a table. Securely clamp one end of a string to the other end of the table.
2. Tie the other end of the string around a mass hanger. Lay the string over the pulley. Place a pencil under the
string near the clamp, so the string can vibrate without hitting the table, as shown in the drawing.

3. Hang one 500-g mass on the mass hanger. Pluck the string, listen to the sound, and observe the string vibrate.
   a) Record your observations in your log in a table similar to the following:

<table>
<thead>
<tr>
<th>Length of vibrating string</th>
<th>Load on mass hanger</th>
<th>Pitch (high, medium, low)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Use a key or some other small metal object. Press this object down on the string right in the middle, to hold the string firmly against the table. Pluck each half of the string.
   a) Record the result in your table.

5. To change the string length, press down with the key at the different places shown in the diagrams on the next page. Pluck each part of the string.
   a) Record the results in your table.
6. When you pluck the string, it does not move at the ends. Look at the drawing under Step 9 of the For You To Do section in Activity 1. Measure the length of your string, and find the wavelength of the vibration for each string length.
   a) Record the wavelength in your table.
   b) Look over the data in your table. Make a general statement about what happens to the pitch you hear as you change the length of the string.

7. Remove the key, so the string is its original length. Pluck the string. To investigate the effect of tightening the string, add a second 500-g mass to the mass hanger. Pluck the string again, observe the vibration, and listen to the pitch of the sound.
   a) Make up a table to record your data in your log.
   b) Add a description of the pitch of the sound to your table. Continue adding weights and observing the sound until the total mass is 2000 g.
   c) Look over your data. As the mass increases, the string becomes tighter, and its tension increases. Make a general statement about what happens to the pitch you hear as you change the tension on the string.
FOR YOU TO READ

Changing the Pitch

Sound comes from vibration. You observed the vibration of the string as it produced sound. You investigated two of the variables that affect the sound of a vibrating string.

When you pushed the vibrating string down against the table, the length of the string that was vibrating became shorter. Shortening the string increased the pitch (resulted in a higher pitch). In the same way, a guitarist or violinist pushes the string against the instrument to shorten the length that vibrates and increases the pitch.

When you hung weights on the end of the string, that increased the pitch too. These weights tightened the string, so they created more tension in it. As the string tension increased, the pitch of the sound also increased. In tuning a guitar or violin, the performer changes the string tension by turning a peg attached to one end of a string. As the peg pulls the string tighter, the pitch goes up.

Combining these two results into one expression, you can say that increasing the tension or decreasing the length of the string will increase the pitch.

The string producing the pitch is actually setting up a standing wave between its endpoints. The length of the string determines the wavelength of this standing wave. Twice the distance between the endpoints is the wavelength of the sound. The pitch that you hear is related to the frequency of the wave. The higher the pitch, the higher the frequency. The speed of the wave is equal to its frequency multiplied by its wavelength.

\[ v = f \lambda \]

where \( v \) = speed
\( f \) = frequency
\( \lambda \) = wavelength

If the speed of a wave is constant, a decrease in the wavelength will result in an increase in the frequency or a higher pitch. A shortened string produces a higher pitch.

Reflecting on the Activity and the Challenge

Part of the Chapter Challenge is to create a sound show. In this activity you investigated the relationship of pitch to length of the string and tension of the string: the shorter the string, the higher the pitch; the greater the tension, the higher the pitch. You also learned that the string is setting up a standing wave between its two ends, just like the standing wave that you created in the Slinky in Activity 1. That’s the physics of stringed instruments! If you wanted to create a stringed or multi-string instrument for your show, you would now know how to adjust the length and tension to produce the notes you want. If you were to make such a stringed instrument, you could explain how you change the pitch by referring to the results of this activity.

Physics Words

pitch: the quality of a sound dependent primarily on the frequency of the sound waves produced by its source.
Physics To Go

1. a) Explain how you can change the tension of a vibrating string.
   b) Tell how changing the tension changes the pitch.

2. a) Explain how you can change the length of a vibrating string.
   b) Tell how changing the length changes the sound produced by the string.

3. How would you change both the tension and the length and keep the pitch the same?

4. Suppose you changed both the length and the tension of the string at the same time. What would happen to the sound?

5. a) For the guitar and the piano, tell how a performer plays different notes.
   b) For the guitar and the piano, tell how a performer (or tuner) changes the pitch of the strings to tune the instrument.

6. a) Look at a guitar. Find the tuners (at the end of the neck). Why does a guitar need tuners?
   b) What is the purpose of the frets on a guitar?
   c) Does a violin or a cello have frets?
   d) Why do a violinist and a cellist require more accuracy in playing than a guitarist?

7. a) Using what you have learned in this activity, design a simple two-stringed instrument.
   b) Include references to wavelength, frequency, pitch, and standing waves in your description.
   c) Use the vocabulary of wavelength, frequency, and standing waves from Activity 1 to describe how the instrument works.
Stretching Exercises

1. Set up the vibrating string as you did in the preceding For You To Do. This time, you will measure the frequency of the sound. Set up a frequency meter on your computer. Pick up the sound with a microphone. Investigate how changing the length of the string changes the frequency of the sound. Create a graph to describe the relationship.

2. Set up the vibrating string, computer, and microphone as you did in Stretching Exercise 1. This time, investigate how changing the string tension changes the frequency of the sound. Create a graph to describe the relationship.

3. Design an investigation to find how the diameter (thickness) of the string or the type of material the string is made of affects the pitch you hear. Submit your design to your teacher for approval before proceeding to carry out your experiments.