Main Topic	Sound
Subtopic	Music
Learning Level	Middle
Technology Level	Low
Activity Type	Student

Description: Use three simple toy instruments to explore fundamentals of sound and frequency. Inquiry Exercise.

Required Equipment	Boomwhackers, Audioscope software or Sound Sensor (for measuring frequency), Sound Pipe, soda straw, scissors.
Optional Equipment	

Educational Objectives

- Learn the fundamentals of the acoustics of wind instruments
- Calculate the velocity of sound in air.

Concept Overview

Boomwhackers: Students will share a number of colored plastic tubes of various lengths. The objective is to excite them to produce a musical note by whacking them on your knee. (You can also try blowing across the top or tapping the end with your fingers.) Standing sound waves are excited inside the tubes, with wavelengths a little longer than double the length of the tube.

Twirling Pipes: When the soft corrugated hoses, or pipes, are twirled around, they produce a note whose pitch depends upon how fast you can twirl it! You can probably produce only three different pitches, or frequencies. If you know something about music, you will recognize the pitches as representing the musical intervals of a fifth and an octave above the lowest note. The pipes are producing members of a harmonic series (a series of notes whose frequencies are integer multiples of the lowest member, or fundamental). However, these pipes cannot produce the fundamental! This is a strange phenomenon, having to do with the manner in which these tubes produce sound using air turbulence.

Soda Straw Flutes: All that's required for this is a soda straw and a pair of scissors. We will again look for a relationship between pitch and length.

Lab Tips

Students should have already done exercises dealing with vibrations, waves and resonance. Prior knowledge of musical intervals (octaves, perfect fifths, etc…) is helpful.

Korg electronic tuners (any music store, about $20) make wonderful frequency meters! Kids of all ages love Boomwhackers. Let them play intervals with two or three and determine which are consonant and then look at frequency ratios.

Acknowledgement

Adapted from "Pythagoras Sounds Off II: Wind Instruments," an Inquiry Exercise by J. R. Harkay. See www.PhenomenalPhysics.com for more information on the complete Guided Inquiry Curriculum.

Wind Instruments Inquiry Name: ____________________
Class: ______________________

Materials:

Boomwhackers, Audioscope software or Sound Sensor (for measuring frequency), Sound Pipe, soda straw, scissors.

Commentary:

You and your classmates will be sharing a number of colored plastic tubes of various lengths. The objective is to excite them to produce a musical note by whacking them on your knee. (You can also try blowing across the top or tapping the end with your fingers.) Standing sound waves are excited inside the tubes, with wavelengths a little longer than double the length of the tube.

Inquiry:

I. Boomwhackers

1. What do you observe about the length of the tube and the pitch produced by the tube?

2. In the table below, note the length of several tubes and the frequencies they produce.

Length	**Frequency**

3. (Optional, ask your teacher.) Graph frequency versus length. Is it a straight line?

4. (Optional, ask your teacher.) Now graph frequency versus 1/length. Is it a straight line now? Relate what you see on your graph to what you heard.

5. (Optional, ask your teacher.) There is an exact relationship between length and frequency which we can test. It looks like this:

$$Frequency = \frac{speed\ \ of\ \ sound\ \ in\ \ air}{2(length) + 0.6(tube\ \ diameter)}$$

The term that involves the tube diameter represents the "end correction" for the two ends and is the same for all tubes. (When it comes to sound, tubes act longer than they really are.) Measure the length and diameter of a tube and calculate the frequency it "plays" using the above equation. How does your answer compare to the pitch actually produced?

6. Now try this. You have learned about musical intervals for stringed instruments and how the intervals related to the lengths of the strings. Let's see if you can produce musical intervals using the Boomwhacker tubes! You may have to borrow tubes from other groups to do this.
   a. What is the ratio of <u>lengths</u> of tubes that differ by an octave (double the frequency)?
   b. How about a perfect fifth (a frequency ratio of 3/2)? What is the ratio of tube lengths?

II. Twirling Pipes

Now, we play with another common toy. When the soft corrugated hoses, or pipes, are twirled around, they produce a note whose pitch depends upon how fast you can twirl it! You can probably produce only three different pitches, or frequencies. If you know something about music, you will recognize the pitches as representing the musical intervals of a fifth and an octave above the lowest note. The pipes are producing members of a harmonic series (a series of notes whose frequencies are integer multiples of the lowest member, or fundamental). However, these pipes cannot produce the fundamental! This is a strange phenomenon, having to do with the manner in which these tubes produce sound using air turbulence.

7. Twirl your tube and measure the frequency produced. Rank the pitch of the note according to how fast you twirl it.

8. Measure the length of the tube and calculate the frequency of the lowest note, or fundamental, using the equation from the Boomwhackers section above. Record your answer.

9. Multiply the fundamental frequency by 2, 3, and 4. This should result in the pitches you actually heard. Do you agree or not?

10. Now obtain two tubes and play them together. Do you hear the intervals? If you know enough about music to hear intervals, verify whether they exist or not.

11. It would be interesting to have twirling tubes of various lengths. If one did cut off some of the tube (do NOT do this), would it play lower or higher notes?

III. Soda Straw Flutes

All that's required for this is a soda straw and a pair of scissors. We will again look for a relationship between pitch and length.

12. First, use the scissors to cut the straw off on a diagonal so one end looks like a wedge (not pointy, but tapered). This makes that end into a double read (similar to that found in an oboe or bassoon).
13. To play the straw, chew on the reed a bit to soften it. Pinch the reed with your front teeth and blow. This takes some practice! You should be able to produce a high-pitched note.
14. Use the scissors to cut some of the straw off the open end and observe what happens to the note produced. Record your observations.

15. If you have a straw of length L and would like to make it play a note an octave higher, how much should you cut off?

16. Try playing straw flutes together to produce some nice intervals.