Acoustical Society of America

Tuning Fork Discovery with Study of the Science of Sound

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ASA Activity Kit Committee

Students examine a brief history of the discovery of how sound works and then use tuning forks to experiment with how sound works.

Science Topics	Process Skills	Grade Level
Resonance	Scientific Inquiry	6-12
Frequency	Observing	
History of Sound	Comparing	
Conservation of Energy	Predicting	
	Measuring	
	Communicating	
	Inferring	

Time Required

Advanced Preparation	Set-Up	Activity	Clean-Up
Gather materials	5 minutes	45 minutes	5 minutes

Learning Goals

Students will be able to

- Relate the frequency of notes that are an octave apart – twice the frequency
- Identify the frequency of tuning fork that can cause another fork to vibrate/resonate –
- Identify whether a tuning fork will make a low or a high note based on the tine length.
- Describe the transfer of energy from a tuning fork to either another tuning fork or to water.

Materials

- Packet – 1 per student (pages 5-7)
- Tuning forks – 1 per group
- Containers for water
- *PhET Interactive Simulation "Wave on a String"

*optional

Advanced Preparations

- Gather materials.

Please forward any questions or comments to:
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Set Up

- Prepare materials to hand out and use during the lesson.

Introducing the Activity

Students will read the excerpt (see page 5) on the discovery of sound and answer questions 1-5. This will be done at the beginning of class.

- The point to emphasize in the reading is that it took a very long time to discover what creates sound, and to emphasize how tuning forks helped the process along.

Students will answer prediction questions 6 and 7.

Doing the Activity

<u>Tuning Fork Discovery</u>

Students will walk around to other tables and compare their tuning fork to others.

- They should find at least 5 different comparisons using the chart shown below.

Frequency of your fork	Frequency of other fork	Compare Length	Compare Pitch

Students will answer questions 8a and 8b.

Students should test other frequencies of tuning forks to see if one fork that is vibrating can make another fork start vibrating by simply holding them next to each other – do not physically touch them.

> **Warning**: be sure that the quiet fork is *completely* silenced first. Hold the tines firmly in your hand to silence the fork before beginning your

Students will answer question 8c.

Students will answer questions 9 based on the information about the frequencies of tuning forks.

Students will place the tuning fork in a cup of water and then answer question 10. The smaller the cup/bowl used, the bigger the splash will be! Also the lower frequency tuning forks make larger splashes.

Explanation

In-depth background information for teachers and interested students

A musical note one octave higher than the previous is twice the frequency of the previous. For example, middle C is 261.5 Hz and the next C an octave higher is 523 Hz, while the next octave up has a C of 1046 Hz.

A vibrating tuning fork can cause another quiet tuning fork to start vibrating simply by being placed near each other. No need to touch them or to have them both touching a table. The energy transfers through the air. The frequencies of the two forks have to be the same for best results. Frequencies that are near, for example 880 hz and 883 hz, will not work. However, multiples of frequency can work but quietly. For example 440 hz and 880 hz.

The tuning forks included in the ASA Activity Kit for Teachers are all manufactured with the same material so a person can look at the tine length and see that lower frequency tuning forks have longer tines while higher frequency forks have shorter tines.

When a vibrating tuning fork is placed in a bowl of water, the energy from the fork is transferred into the water. If the fork just touches the water, a small amount of water from the top gains kinetic energy and flies out of the bowl. If you dip the fork deeply, the vibrations quit. This is because the energy is transferred to a lot of water which is too heavy to move very fast with the small amount of energy that the tuning fork vibrates with.

Key Terms:

- Frequency – wiggles per second (moves back and forth)
- Resonance – A natural *frequency* of *vibration* determined by the size and shape of an object
- Pitch – How low or high a tone sounds to a person
- Hertz (Hz) – A measure of frequency. The number of oscillations (back and forth movements) per second.

Notes For Teachers

- The point to emphasize in the reading is that it took a very long time to discover what creates sound, and to emphasize how tuning forks helped the process along.

- Question 6 is only appropriate if the set of tuning forks are uniform. If they are different brands or have tuning knobs on the ends, this question won't work.

Optional Extensions /Modifications

Modifications:

- If necessary, the paragraph on the history of sound could be read aloud and the questions afterward can be done through class discussion.

Optional Extensions:

- Art Extension – If you put the tuning fork in a cup of paint (the runnier the paint, the better) it will splash onto a piece of paper

The Study of the Science of Sound and Tuning Forks!

Name: ________________________

From Oracle ThinkQuest website:

In the 6th century BC Pythagoras of Samos observed someone playing a stringed instrument and as he observed the string being plucked, he related the amplitude of its vibration (which he saw as the width of the blurred area the motion of the string produced) with the perceived loudness of the sound. He also noted that when the vibration stopped altogether, the sound stopped as well. He even saw that the shorter strings vibrated more rapidly, and that this more rapid vibration seemed to produce a shriller, higher-pitched sound.

By 400 BC, a member of the Pythagorian school, Archytus of Tarentum was postulating that sound was produced by the striking together of objects. From this he also gathered that a fast motion resulted in a high pitch and slow motion resulted in a low pitch. Though he was on the right track, today we know this to be true only under certain circumstances.

Around 350 BC, Aristotle observed that the vibrating string was actually striking the air. He also concluded that each bit of air struck a neighboring bit of air, which in turn struck another bit, and so on. From this Aristotle hypothesized that air was needed as a medium through which sound could be conducted. He further postulated that sound would not be conducted without a medium; that is, it would not be conducted in a vacuum.

Realizing that a vibrating string strikes the air many times in a series of blows, not just once, 1st century Roman engineer Marcus Vituruvius Pollio suggested that the air not only moved, but vibrated. He thought that it did so in response to the vibrations of the string. He maintained that it was actually these air vibrations that we heard and perceived as sound.

It was not until about 500 A.D. that the connection between the motion of sound and the motion of waves was suggested. The Roman philosopher Anicius Manilius Severinus Boethius specifically compared the conduction of sound through the air to the waves produced by dropping a pebble into calm water. Though today we know that sound waves and water waves represent two distinct types of wave motion, (longitudinal and transverse, respectively) the realization that sound moved as a wave at all was an important step in the study of sound.

The invention of the tuning fork in 1711 by John Shore and its further development by Frenchman Rudolph Köning eased the study of sound considerably. Later breakthroughs in sound were made when, in 1842, Christian Doppler first identified and quantified the change in pitch that occurred when a source of sound moves toward or away from a stationary observer, or an observer moves toward or away from a stationary source of sound. This effect now bears his name and is known as the Doppler Effect. Other modern to contributors to the study of sound included the likes of Helmholtz, Lord Rayleigh, Weber, Fechner, Fletcher, Bekesy and Mach, who observed the Mach cone and whose name gives us the Mach number, which is how fast an object is going compared to the speed of sound.

1. In the first paragraph: What are two concepts about sound waves that are introduced? Draw below what is being described. You can use the “Wave on a String” PhET simulation if you like.

2. What did Aristotle postulate about how sound travels? Draw a picture of how this might look.

3. What did Roman Marcus Vituruvius Pollio add to Aristotle’s postulate?

4. When was it first suggested that sound travels as a wave?

5. What invention really helped scientists study sound?

Tuning Fork discovery

6. *Prediction:* Do you think longer tuning forks have larger or smaller frequencies?

7. *Prediction:* Do you hear a lower or higher pitch with larger frequencies?

8. Walk around to other tables and compare your tuning fork to others. Find at least 5 different comparisons. Try and determine a) how fork length relates to frequency and b) how frequency relates to the pitch that you hear.

Frequency of your fork	**Frequency of other**	**Length (compare)**	**Pitch (compare)**

a. How does fork length compare to frequency based on your above observations?

b. How does the pitch that you hear compare to the frequency of the tuning fork?

Now test other frequencies of tuning forks to see if one fork that is vibrating can make another fork start vibrating by simply holding them next to each other – do not physically touch them. (Warning: be sure that the quiet fork is *completely* silenced first. Hold the tines firmly in your hand, to silence the fork, before beginning your test)

c. Which pairs of forks, if any, can make another vibrate? You may have to go back and ask other people what they found.

The 261.6 Hz fork is “middle C” and the 523.2 Hz fork is the C one octave higher on the musical scale. The 440 Hz fork and the 880 Hz forks both make an A note on the musical scale.

9. Based on the above information, how do the frequencies of notes an octave apart compare?

10. What happens if you place a tuning fork on/in calm water? Does it depend on your technique or the frequency of the fork?