# Waves We Measure: Electromagnetic or Mechanical?

## *Overview:*

Light is an electromagnetic wave. In contrast, sound is a type of mechanical wave. Sounds can be produced at a range of frequencies, from the infrasonic (below the range of human hearing) to the ultrasonic (above the range of human hearing). Scientists are investigating how the patterns of infrasonic sounds produced by volcanoes may predict eruptions. In this activity, students investigate the properties of sound waves.

## *Objectives:*

The student will:

- explain how an electromagnetic wave differs from a mechanical wave;
- investigate the relationship between frequency and vibration rate; and
- calculate the distance to a hypothetical object using properties of sound.

## *Materials:*

- Tuning fork
- Mallet
- Large bowl (at least 12 inch diameter)
- Plastic rulers
- Transparency: "Sound Waves"
- Student Worksheet: "Sound and Vibration"

## *Answers to Student Worksheet:*

1. lower
2. decrease
3. decrease
4. An electromagnetic wave does not need a medium; a mechanical wave must travel through solid, liquid, or gas.
5. Frequency measures the rate of vibration, or number of waves per second that pass a stationary point. Speed measures how far a wave travels in a period of time.
6. 240.8 meters
7. No, speed is independent of frequency.

 

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## *Activity Procedure:*

1. Ask students to place their fingers on their throats and hum. What do they feel? Why is this happening? If necessary, explain that the vibrations coming from the larynx are responsible for producing sound waves.
2. Define a wave (a disturbance that transfers energy from one place to another, but not matter). Remind students that there are two types of waves: electromagnetic and mechanical. Electromagnetic waves do not need a medium to in order to travel: they can travel through the vacuum of space. In contrast, mechanical waves must travel through a medium. Write these concepts on the board.
3. Ask students if they think that sound waves are electromagnetic or mechanical and why (they may answer electromagnetic, but sound waves use a medium: air! They can also travel through liquids and solids, as well as gases).
4. Strike a tuning fork with a mallet, and then dip it into a bowl of water. Students should observe the ripples propagating outward from the tuning fork. Explain that sound waves propagate through air in a similar way, even though we cannot see them. Make sure students understand that energy is traveling through the water—the water itself is not traveling.
5. Display the Transparency: “Sound Waves.” Explain that sound waves are described in frequencies. Frequency of a sound wave is perceived as pitch by human ears. Low-frequency waves are low-pitched, while high-frequency waves are high-pitched. Frequency is the number of waves that pass a point per second (units of frequency are Hertz). For instance, if a sound has a frequency of 10 Hertz that means that 10 waves pass a stationary point in 1 second. Write this information on the board for reference.
6. Explain that some sound waves are too low or too high to be heard by the human ear. Volcanoes, for instance, produce sounds in the “infrasonic” range: below 20 Hertz. Scientists are studying these sounds to see if they can aid in predicting volcanic eruptions.
7. Explain that ultrasonic sounds, those too high for the human ear to hear, are often used in animal echolocation. Because sound travels as a wave, it can be reflected off of surfaces, just as light waves can be reflected. An echo is a reflection of sound. Animals tell how far away an object is by making a sound and judging how long it takes for the echo to return.
8. Distinguish “frequency” from “speed” of a wave: frequency measures how often the particles around a wave vibrate, while speed measures how far a wave travels in a period of time. Sound wave speed is independent of frequency: thunder and field cricket chirps both travel at about 344 meters/second (750 miles per hour) in air at normal temperature.

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**Extension Idea:** Navigate to the websites listed below to let students hear how scientists have translated infrasonic volcanic sounds into music: The sound of Mt. Etna volcano in Italy translated into a melody (http://grid.ct.infn.it/etnasound/page4/page8/etna.aif). The sound of Tungurahua volcano in Ecuador translated into a melody (http://grid.ct.infn.it/tungurahuasound/TunguScore.mid).

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**Name:________________________________________** **Student Worksheet**

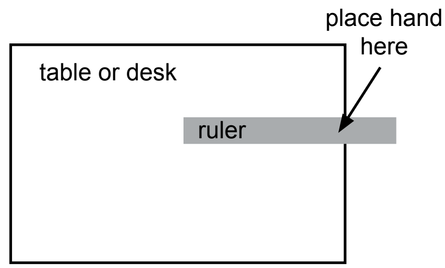
# Sound and Vibration

### *Background Information:*

The pitch of a sound can be used to estimate the frequency of a sound wave. High-pitched sounds have high frequencies, while low-pitched sounds have low frequencies. Wave frequency is different than wave speed: frequency measures how often the particles around a wave vibrate, while speed measures how far a wave travels in a period of time.

### *Materials:*

Plastic ruler

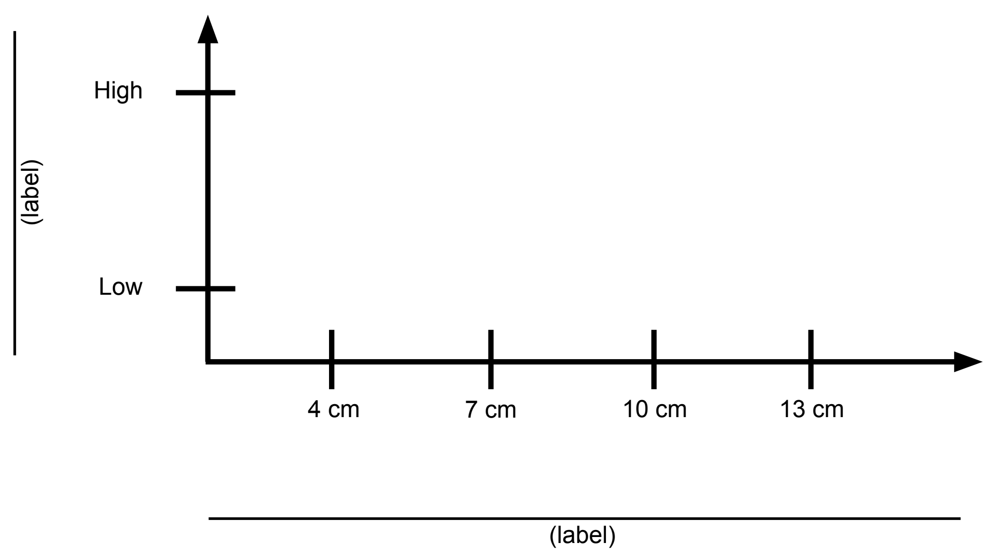



### *Procedure:*

1. Place a plastic ruler on a desk with about 4 centimeters of the ruler hanging over the edge.
2. Put pressure on the ruler with a hand to hold it into place. The hand should be placed very close to the edge of the desk as shown.
3. With one finger of the other hand, firsy press the end of the ruler and release it so it vibrates. Listen to the frequency of the sound the vibration makes, and watch the vibration closely.
4. Adjust the ruler so that 7 centimeters of the ruler hang over the edge of the desk. Hold it in place as before, and listen and watch the vibrations carefully.
5. Repeat the procedure with 10 centimeters and 13 centimeters hanging over the edge of the desk.

### *Data:*

The y-axis on the graph below represents frequency. Plot how frequencies of the sounds differ as more of the ruler is extended off of the desk. (Please label the Y-Axis "Frequency" and the X-Axis "Amount of Ruler Off of Desk")



**Name:______________________________________** **Student Worksheet**

# Sound and Vibration

## *Questions:*

1. Is the frequency generally higher or lower as more of the ruler is extended off of the desk?

   ______________________________________________________________________

2. Does the vibration rate increase or decrease as more of the ruler is extended off of the desk?

   ______________________________________________________________________

3. Does frequency increase or decrease as vibration rate decreases?

   ______________________________________________________________________

4. Explain, in your own words, how an electromagnetic wave, such as visible light, differs from a mechanical wave, such as sound.

   ______________________________________________________________________

   ______________________________________________________________________

5. What is the difference between frequency of a wave and speed of a wave?

   ______________________________________________________________________

   ______________________________________________________________________

6. The distance to an object can be calculated by using the time it takes for an echo to be heard:

   *Distance = speed of sound x 1/2 time for echo to return*

   A person is standing at an unknown distance from a wall. We want to know how far away the wall is from the person. The speed of sound is 344 meters per second. The person yells, and the echo takes 1.4 seconds to return. How far away is the wall in meters? Show calculations below.

7. Will changing the frequency of the sound change the speed at which it travels? Why or why not?

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   ______________________________________________________________________

 