Sound Resonance in Microgravity

Introduction:

You may have seen videos of large bridges swaying in the wind, or a singer's voice causing a glass to shatter. This occurs due to resonance. Resonance is where the energy from movement is transferred to a substance, causing it to vibrate. This can be seen when a building vibrates as a large vehicle passes by. Watch this video for a great (and fun) explanation! A Better Description of Resonance (Steve Mould)

On the International Space Station, Astronaut Don Pettit demonstrates how water reacts to sound waves of varying frequencies and amplitudes in microgravity. The results are very cool! Don Pettit Sounds in Space

It is easy to demonstrate how sound resonates in a classroom using simple tuning forks and water. How would you visualize this in space?

Materials:

Set of tuning forks of different frequencies
Plastic container
Water
Tray
Droppers
Beakers / Measuring Cups
Paper towels

Key Lesson Terminology

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.

Target grade level: 6th-8th grade
Suggested time frame: 45 minutes

NGSS (Next Generation Science Standards)

HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. model, and that for some situations one model is more useful than the other.
MS-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.
MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Objectives

- To explore the concepts of sound waves, frequency, energy transfer, and resonance using water and an assortment of tuning forks.

- Design and build an apparatus to demonstrate the effect of resonance in microgravity on board G-Force One

Engage

Tuning forks are musical instruments that produce sound waves at specific frequencies. Engage students by striking a tuning fork against a hard surface and hold it close to their ear to hear the sound it produces.

1. Fill a small container with water and place it on a tray. Explain to students that sound waves can travel through water and demonstrate by dropping a dropper or pipette in the water and listening to the sound it produces.

2. Using the measuring cups, measure out 50 mL of water and pour it into the container.

3. Ask students to observe what happens to the water when you strike the tuning fork and hold it near the surface of the water. Explain that the sound waves from the tuning fork are causing the water to vibrate, which creates ripples and waves.

Purpose How do changes in frequency of a tuning fork affect the vibration of water?

Hypothesis

Procedures

1. Fill a small container with water and place it on a tray.

4. Using the measuring cups, measure out approximately 50 mL of water and pour into the container.

5. Strike each tuning fork and order the tuning forks in terms of pitch. Record observation on data sheet. *What is the relationship between pitch and frequency?*

6. One at a time, strike each tuning fork and hold it near the surface of the water. Record results in a table regarding frequency of the tuning fork and pattern of the waves in the water.

Results

Frequency of tuning fork	Length of tuning fork (cm)	Pitch (order from low to high)	Observations

Assessment

1. How is this experiment an example of resonance?
2. How does length of fork compare to frequency?
3. How does the pitch that you hear compare to the frequency of the tuning fork?
4. What happens when you place a tuning fork next to water? Explain.
5. How does changing the frequency affect the motion of water? Explain.
6. Illustrate and describe the sound waves for low frequency versus high frequency. What is the relationship between frequency and energy?
7. Reflect about real-world examples of resonance, such as musical instruments, bridges, and buildings. How can the knowledge of resonance be applied?

Design an experiment for space!

Liquids behave very differently in space than on earth. Therefore, it is difficult to measure the amount of a liquid, such as fuel, in microgravity. Scientists are working with resonance to determine how much fuel is in a tank during space flight.

Your job is to:

- Design a system to test and measure resonance in microgravity.
- Demonstrate how this system can by used to determine amount of liquid in a container during spaceflight.

Extensions

- Investigate how the size and shape of the container affect the patterns of the waves in the water
- Create a piece of art using tuning forks and paint!
- Research how resonance is used in different fields, such as medicine (ultrasound), music, and engineering
- Create your own musical instrument using resonance, such as a water xylophone (using glasses with different levels of water for each pitch)

Resources

https://phet.colorado.edu/en/simulations/wave-on-a-string

https://phet.colorado.edu/en/simulations/waves-intro

https://www.youtube.com/watch?v=f99MnB7vfIQ

https://www.youtube.com/watch?v=5H8aRCyEGnU