SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Acoustic Resonance, Interference, and Standing Waves **Grade 11 – Waves and Sound**

Lesson Plan

Assessment	AFL, AOL
Cross-curricular	

Big Ideas

- Mechanical waves can affect structures, society, and the environment in positive and negative ways.

Learning Goals

- I know the terms superposition, constructive interference, destructive interference, standing waves and resonance.
- I can explain how resonance is used in a variety of situations.
- I can demonstrate resonance and calculate harmonic frequencies and wavelengths.
- I know the Superposition Principle and can use it to find the wave resulting from the interference of two individual waves.

Specific Expectations:

E2. investigate, in qualitative and quantitative terms, the properties of mechanical waves and sound, and solve related problems;
E2.1 use appropriate terminology related to mechanical waves and sound, including, but not limited to: longitudinal wave, transverse wave, frequency, period, cycle, amplitude, phase, wavelength, velocity, superposition, constructive interference, destructive interference, standing waves, and resonance
E2.2 conduct laboratory inquiries or computer simulations involving mechanical waves and their interference
E2.7 analyse the conditions required to produce resonance in vibrating objects and/or in air columns (e.g., in a string instrument, a tuning fork, a wind instrument), and explain how resonance is used in a variety of situations
E3. demonstrate an understanding of the properties of mechanical waves and sound and of the principles underlying their production, transmission, interaction, and reception.
E3.2 explain the components of resonance, and identify the conditions required for resonance to occur in vibrating objects and in various media
E3.4 identify the properties of standing waves, and, for both mechanical and sound waves, explain the conditions required for standing waves to occur

Description:
In this lesson students will do a resonance experiment using a wine glass and an oscilloscope. Students will calculate harmonic frequencies and wavelengths. This lesson should occur after students have learned about sound as a mechanical wave. **This lesson is intended for the university level.**

Materials

Acoustic Resonance and Interference visuals
Watching Tibetan Bowls Sing video
Sand Vibrations Pattern–Chladni Plate video
Julie Andrews breaking glass with high note (Victor Victoria) video
Breaking Glass with Sound video
Tacoma Narrows Bridge Collapse video
Tuning Forks video
Scientists Create Working Tractor Beam video

Resonance of a Wine glass Group Materials

- Wine glass
- Water
- Oscilloscope app on a tablet or computer

Resonance Superposition and Standing Waves (Student and Teacher)

Safety Notes

Students should dispose of broken glass in the appropriate glass disposal box/container.

Introduction

Students have learned that sound is a *mechanical wave*, a disturbance in a medium which propagates and transfers energy through the medium. A wave has a characteristic *frequency* -- this is the number of cycles or oscillations per second. The frequency at which any object vibrates when not driven or damped is called its *natural frequency*. *Resonance* is when one object causes another to vibrate at its natural frequency and results in a dramatic increase in the amplitude of the resultant vibrations.

Use the *Acoustic Resonance and Interference visuals* to learn more about resonance, interference, and standing waves (See Link).

The teacher should bring in singing bowls if he/she has access to them. A flute, trumpet, trombone, guitar, could also be a useful demonstration tool as the fundamental frequency plus multiple harmonics can be played.

Start out by having students watch the videos showing examples of resonance, the setting up of standing waves and the effects of these phenomena. Ask students if these videos have anything in common or how they are different and how they think these effects are occurring.

Watching Tibetan Bowls Sing
https://www.youtube.com/watch?v=oob8zENYt0g
Institute of Physics
Creative Commons Attribution License
Uploaded June 5, 2011
Retrieved February 6, 2016

Sand Vibrations Pattern – Chladni Plate
https://www.youtube.com/watch?v=YedgubRZva8
Saint Mary's University Physics
June 23, 2009
Retrieved February 6, 2016

Julie Andrews breaking glass with high note (Victor Victoria)
https://www.youtube.com/watch?v=f_P6co4aTik
Retrieved February 6, 2016

Breaking Glass with Sound
http://video.mit.edu/watch/breaking-glass-with-sound-3947/
MIT Department Of Physics Technical Services Group
Creative Commons Attribution License
Uploaded May 27, 2009
Retrieved February 6, 2016

Tacoma Narrows Bridge Collapse
https://archive.org/details/SF121
Stillman Fires Collection; Tacoma Fire Department (Video) - Castle Films (Sound)
Public Domain
Published 1940
Retrieved February 6, 2016

After giving these examples of resonance, the teacher should introduce the concept of natural frequency by tapping a wine glass, hitting a tuning fork, and/or blowing across the top of a bottle. These items resonate at their own natural frequency. If the teacher has access to two tuning forks of identical frequency, he/she can do the demonstration shown in the Tuning Forks video.

Tuning Forks
https://www.youtube.com/watch?v=aCocQa2Bcuc
MIT Department of Physics Technical Services Group
June 25, 2012
Retrieved February 6, 2016

The teacher can also have two students holding a long slinky or rope, set up a standing wave by having one of the students begin pulsing the rope at a regular frequency until they produce a standing wave. They should be able to produce the fundamental frequency (one antinode) and then at least the first harmonic (showing one node). Finally, the teacher can introduce an unbelievable new technology whereby scientists have developed a process to levitate objects using the interference of high frequency audio waves: *Scientists Create Working Tractor Beam* video.

http://www.cnn.com/videos/tech/2015/10/28/tractor-beam-created-star-trek-orig-vstan.cnn
CNN: The World of Technology

October 28, 2015
Retrieved February 6, 2016

Students should answer the discussion questions in the *Acoustic Resonance and Interference visuals* in pairs and come up with a potential future use for acoustic resonance.

Action

Resonance of a Wine Glass

In groups of three, you will now experiment with the resonance of a wine glass.

Group Materials

- Wine glass
- Water
- Oscilloscope app on a tablet or computer

Instructions

1. Wet your finger and attempt to make the wine glass resonate.
2. Use the oscilloscope to determine the natural frequency of the wine glass.
3. Calculate the wavelength of the natural frequency.
4. Determine the third and fifth harmonics using calculation.
5. Now lower the frequency of the wine glass by 150 Hz by adding water.
6. Determine the lowest frequency that can be made by the glass and show it to your teacher.

Complete the following chart:

Fundamental Frequency:	**Hz**	**Wavelength:**	**m**
3rd Harmonic Frequency:	Hz	Wavelength:	m
5th Harmonic Frequency:	Hz	Wavelength:	m
Fundamental–150 Hz =	Hz	Wavelength:	m
Lowest Frequency:	Hz	Wavelength:	m

Consolidation/Extension

Finally, students should complete the assignment on Resonance, Superposition, and Standing Waves for homework (See Link).