Teacher Toolkit - The Nature of Sound

Objectives:

1. To describe sound as a longitudinal, mechanical, pressure wave that is produced by a vibrating object.
2. To understand the concept of frequency as the number of back-and-forth oscillations of a particle about its resting position and to relate the frequency of sound to the pitch.
3. To relate the intensity of a sound wave to the amplitude of vibration of the particles of the medium and to use the deciBel equation to calculate intensity or the deciBel level.
4. To know that the speed of sound (like any wave) is dependent upon the properties of the medium, to compare the speed of sound in a solid, liquid, and gas, and to relate the speed of sound to the frequency and wavelength of the sound wave.

Readings:

The Physics Classroom Tutorial, Sound Waves and Music Chapter, Lesson 1
The Physics Classroom Tutorial, Sound Waves and Music Chapter, Lesson 2

Interactive Simulations:

1. Simple Wave Simulator http://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/Simple-Wave-Simulator
   The Simple Wave Simulator provides an excellent introduction to the nature of a mechanical wave. The simulator allows a learner to explore both waves traveling through strings and sound waves traveling through air. The learner may control the frequency, speed, and amplitude of the vibrations. The pattern of crests and troughs are shown for the string wave. We highly recommend the accompanying exercise. The exercise guides the learner to key observations and concludes with a short quiz that assesses key understandings.
2. Sound https://phet.colorado.edu/en/simulation/legacy/sound
   This simulation from PhET has several usage modes. Tapping a tab at the top of the simulation allows one to toggle from one mode to another. Many of the uses are appropriate for the topic of the Nature of Sound. Learners clearly see the compressions and rarefactions produced by a vibrating speaker. While the simulation has great value, it is currently available only as a Java Applet and thus not useable on mobile devices, iPads or Chromebooks. We expect that eventually an HTML5 alternative will become available.
3. Sound Waves http://www.iknowthat.com/ScienceIllustrations/sound/science_desk.swf
   This Flash simulation provides learners with an appealing interface for exploring the nature of Sound Waves. We particularly like the interactive glass tapping simulation. Tap a glass and hear the sound of its vibrations, view the wave form on an oscilloscope, and observe its frequency. Tap a different glass with a different size and observe the difference in frequency and sound. Regrettably, the simulation is a Flash simulation and has limited functionality on modern devices and in modern browsers.

Video and Animation:

1. Transmission of Sound https://www.youtube.com/watch?v=GkNJvZINSEY
   This 5-minute video from Designmate discusses the production and transmission of sound waves. Longitudinal waves are discussed and compared to transverse waves. Their transmission at different speeds in different media are discussed and animated. The importance of the particle-to-particle interaction in the transmission through solids, liquids, and gases are explained. Frequency, wavelength, and amplitude are explained.
2. The Loudest and Faintest Sounds http://thekidshouldseethis.com/post/whats-the-loudest-possible-sound-its-okay-to-be-smart
   This video from Joe Hanson and It's Okay to Be Smart dives into the wide ranging and incredibly sensitive world of sound waves.
3. Paint on a Speaker by Slo-Mo Guys https://www.youtube.com/watch?v=5WKU7gG_ApU
   The Slo-Mo Guys place lots of colored, latex paint on a speaker and set it into vibration and record the vibrations using a slow motion video camera. The intriguing collection of video clips will make for an eye-catching classroom tool for capturing physics students' attention as you begin a unit of study on the topic of waves and sound.
4. The Coolest Things Sound Waves Do https://www.youtube.com/watch?v=Ude8pPjawKI
   This 3-minute YouTube video discusses the use of sound resonance to break a wine glass, the use of ultrasound in levitation technologies, and the use of sound as a weapon (Long Range Acoustical Device).

Labs and Investigations: http://www.physicsclassroom.com/lab/sound/Slabs.cfm

1. The Physics Classroom, The Laboratory, Listen Up!
2. The Physics Classroom, The Laboratory, Mach 1

Demonstration Ideas:

1. Clap to the Beat and Measure the Speed of Sound https://www.youtube.com/watch?v=CNnpPZMxHq4
   This Direct Measurement Videos (DMV) shows 9 students along a line with each student spaced 10 meters apart. The first student synchronizes her hand-clapping to the sound of a metronome. With eyes closed, each consecutive student synchronizes their hand clap with the sound of the first student's (and thus other students') claps. Using the frame counter and frame rate, one can determine the speed of sound.
2. The Stadium Wave http://giant.gfycat.com/SociableSameIriomotecat.gif
   This short video is the military version of the Stadium Wave. The demonstration provides a strong visual reinforcement of how a wave can move from one location to another without any movement of matter from the source to the destination.
3. Tuning Fork Vibrations https://www.youtube.com/watch?t=79&v=VCERs0v1OoI
   This slow-motion video shows the vibrations of the tines of a tuning fork at 1600 frames per second.

Minds On Physics Internet Modules: http://www.physicsclassroom.com/calcpad/sound

The Minds On Physics Internet Modules are a collection of interactive questioning modules targeting a student's conceptual understanding. Questions are accompanied by detailed help addressing the various parts of the question.

1. Sound and Music, Ass't SM1 - The Nature of a Sound Wave
2. Sound and Music, Ass't SM2 - Characteristics of Sound Waves
3. Sound and Music, Ass't SM3 - Sound Intensity and Decibels

Concept Building Exercises: http://www.physicsclassroom.com/curriculum/sound

1. The Curriculum Corner, Sound Waves, The Nature of Sound Waves
2. The Curriculum Corner, Sound Waves, Properties of Sound Waves
3. The Curriculum Corner, Sound Waves, The Speed of Sound
4. The Curriculum Corner, Sound Waves, Sound Intensity and the Decibel System

Problem-Solving Exercises: http://www.physicsclassroom.com/calcpad/sound

1. The Calculator Pad, Sound and Music, Problems #1-11

Science Reasoning Activities: http://www.physicsclassroom.com/reasoning/sound

1. Intensity and the Decibel System
2. Sound Loudness and the Sone Scale

Real Life Connections: **See Complete Toolkit on Website for Further Details**

1. Glass Harmonica http://thekidshouldseethis.com/post/43232464676
2. How Loud is Too Loud? http://visual.ly/how-loud-too-loud
3. The Visual Microphone https://www.youtube.com/watch?v=FKXOucXB4a8

Common Misconceptions **See Complete Toolkit on Website for Further Details**

1. Sound Waves Require the Movement of Matter from One Location to Another

Elsewhere on the Web: **See Complete Toolkit on Website for Further Details**

1. A Room Built for Total Silence http://motherboard.vice.com/read/inside-a-room-built-for-total-silence
2. The Loudest Speaker in the World http://www.noiseaddicts.com/2008/09/loudest-speaker-in-the-world/

Standards: **See Complete Toolkit on Website for Further Details**

A. Next Generation Science Standards (NGSS) – Grades 9-12

Disciplinary Core Ideas - High School - Wave Properties

Crosscutting Concepts - Patterns, Energy

Science and Engineering Practices

- **Practice #2: Developing and Using Models**
- **Practice #3: Planning and Carrying Out Investigations**
- **Practice #4: Analyzing and Interpreting Data**
- **Practice #5: Using Mathematics and Computational Thinking**
- **Practice #6: Constructing Explanations**