"Sound and Frequency"

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I. DCPS Standards:

8.1.2 Apply simple mathematical models to problems.
8.8.2 Explain how a mechanical wave is a disturbance that propagates through a medium.
8.8.3 Explain how electromagnetic waves differ from mechanical waves in that they do not need a medium for propagation.
8.8.4 Investigate and explain how sound in a fluid (*e.g.* air) is a longitudinal wave.

II. Goals:

Students will understand that sound is a longitudinal wave.
Students will recognize the relation of frequency of the sound waves to the pitch heard.

III. Objectives:

Students will demonstrate knowledge of the relation between wavelength, frequency and velocity.

IV. Prerequisite Knowledge: Sound waves are **longitudinal** waves, meaning that the wave's disturbance is parallel to the direction of propagation. The distance between maximum values ("peaks") of successive disturbances is the **wavelength** of the wave. The time measured by a stationary observer between one peak and the next that he/she hears is called the **period** of the wave, and the reciprocal of the period is the wave's **frequency**. A wave with wavelength λ, and frequency f travels with speed $v=f\lambda$. The frequency of the sound wave determines the pitch heard; lower pitched sounds have a lower frequency than higher pitched sounds. The loudness of the sound however, is related to the size of the disturbance that propagates, called the **amplitude**.

Sound waves are examples of **mechanical waves** because they require a medium in which to propagate; this medium can be solid liquid or gas. There are some waves that do not require a medium to propagate; they can travel through an empty vacuum, such as outer space. The most familiar example is electromagnetic waves, which include light. This travel that can proceed through empty space (but can also proceed through a medium) is often called radiation.

V. Essential Questions:

What is the primary factor determining the pitch of a sound? Is it distinct from the primary factor that determines loudness?

VI. Materials: One or several tuning forks; slinky (optional).

VII. Differentiating Instruction: This activity should pose no problem to speakers of English.

VIII. Rationale: This activity illustrates the fundamental relationship between frequency and pitch.

IX. Activity Procedure: As time permits the instructor explains (or the students read) the background information described above. This includes background on waves in general and sound waves in particular. If a slinky is obtainable, a student volunteer can demonstrate longitudinal waves with it. This serves to emphasize the physical appearance of the waves, which contrasts with the depiction of a typical displacement vs. position graph. Such a graph can be misleading because it appears to represent a transverse wave. The instructor and/or volunteers strike a pair of tuning forks and the class is asked which pitch sounds higher. They can then be asked which they thing has the higher frequency.

X. Evaluation and Assessment: The instructor lists the frequencies of the tuning forks. What does this say about the relationship of pitch to frequency? [Higher frequency means higher pitch; Lower frequency means lower pitch.] What determines how loud the sound from the tuning forks is? [Primarily the amplitude of the waves, which is related to how forcefully the tuning fork was struck initially. However, the some people's ears may be more sensitive to certain frequencies than others, which could play a role if the forks are struck in the same way.] Optional: What does frequency correspond to in light waves? [The color of the light.] Optional: If two sound waves have the same velocities but different frequencies, what does that say about their wavelengths? [They're different; the higher frequency wave has a shorter wavelength and vice versa.] Students write their own statement in their lab notebooks saying what this demonstration has shown them about frequency of waves.