Workshop Tutorials for Introductory Physics

WI4: **Sound**

A. Review of Basic Ideas:

Use the following words to fill in the blanks:
Velocity, rigid, frequency, travelling, elastic, ultrasound, infrasound, elephants, amplitude, higher, Doppler, velocities, standing, medium, decreases, frequencies, longitudinal, water, vibrations

Sound

Sound waves are _____ waves. They require a _____ to propagate through, and the _____ at which they propagate depends on the _____ and inertial properties of the medium. Sound travels faster in more _____ mediums such as _____ and rock than it does in air.

A sound wave can be characterised by its pitch, which depends on the wave's _____, and its volume, which depends on the _____ of the wave.

When a guitar string is plucked or a violin string is bowed, _____ waves on the string reflect from the fixed ends and set up standing waves. These _____ of the string cause the air to vibrate, which is transmitted to our ears as sound waves. Travelling sound waves can also produce _____ waves in air columns, this is how woodwind instruments work.

Humans can hear frequencies in the range 20 Hz – 20 kHz, although this range usually _____ with age. Sound waves with frequencies above 20 kHz are called _____, and are used for medical imaging. Many animals also hear and use ultrasound. Sound waves with frequencies below 20Hz are called _____**.** While we can't hear infrasound, it can cause headaches. Earthquakes produce waves of infrasound, and _____use infrasound to communicate over long distances.

When a police car with its sirens blaring overtakes you on the road, you hear a range of _____**.** When it is coming towards you it sounds _____in pitch than it does after it has overtaken you. This is called the _____ effect. This effect is used to measure _____ of moving objects, for example a police radar detector uses the Doppler effect to tell if you are speeding, and bats use it to catch insects.

Discussion Question
In some science fiction movies, for example the Star Wars series, the explosion of a spaceship can apparently be heard in another spaceship, while both are in the vacuum of space. Is this possible?
Is there any way the explosion can produce sound inside the second ship?

B. Activity Questions:

1. Tuning forks and beats.

Listen to the beats when you tap the two tuning forks.
What happens when you adjust the frequency of one of the forks?
How do musicians use tuning forks to tune their instruments?

2. Resonance in a tube.

When the tube is the right length, the column of air inside it will resonate with the tuning fork. Vary the length of the air column in the tube to find the wavelength of the sound.
Can you think of a musical instrument which produces different notes by varying the length of an air column?

3. Look and listen

The CRO (cathode ray oscilloscope) draws a graph showing variations in amplitude with time (also used to measure heart rhythms).

Describe what happens to the sound you hear and the pattern on the CRO as the frequency is increased/ decreased? Remember that the audible frequency range is from 20Hz to 20 kHz.

What happens to the sound and the pattern as you turn the amplitude control?

4. Visualising Speech

A microphone is connected to an oscilloscope (CRO). As you speak into the microphone the pattern on the CRO depicts the sound waves generated by you.

a. How do these compare with the signals in (a). Is there more than one frequency?

b. How does the pattern change when you whistle, scream, sing a note, speak softly, speak loudly?

c. A wave appears on the screen if you lightly 'tap' the microphone. Explain why this happens.

C. Qualitative Questions:

1. Resonance is a remarkably useful phenomenon. For example, it is used to create images of body tissues using Magnetic Resonance Imaging, and to heat up food in a microwave. However resonance can also be quite destructive, and marching soldiers always break step crossing bridges, just in case they make the bridge collapse.

a. Explain how a wine glass can be shattered by a sustained note from an opera singer.

b. How is the shattering of a shop window by an explosion some kilometres away different to the shattering of the wine glass, and what sort of wave is involved in this case?

2. The outer ear canal is open to the air at one end and closed by the ear drum at the other end.

a. sketch the pressure distribution wave in the ear canal for the fundamental frequency.

b. sketch the displacement distribution wave in the ear canal for the fundamental frequency and write the wavelength in terms of the length l of the ear canal.

c. sketch the displacement distribution waves in the ear canal for the next two resonant frequencies and write the wavelengths in terms of l.

D. Quantitative Question:

Your local council is considering a proposal to locate a new airport near your house. A representative of the company has claimed that it will only increase ambient day time noise by 3dB, and night time noise levels by 6dB. What factor increases in sound level do these increases correspond to?