LAB 19. SOUND

Equipment

Pair of resonance boxes, rubber mallet; set of boomwhackers; corrugated singing tube; open-ended cylinder with adjustable water level, meter stick; set of tuning forks

Activities

1. Resonance Boxes

Use a rubber mallet to strike a fork mounted on one of the resonance boxes and observe that sound emanates from the box opening. The box "amplifies" the sound of the fork by an action called **resonance**.

1. Place two resonance boxes about a few centimeters apart with open ends facing each other. Sharply strike the fork of *one* of the boxes. Wait a few seconds and then gently hold the fork to stop its vibration. Now, feel the tines of the fork on the *other* box. What do you feel?
2. Repeat this procedure listening at the opening of the other box rather than feeling the tines of the fork on that box. What do you hear?
3. What was happening with the second tuning fork?
4. Mash a ball of clay the size of a peanut kernel on each tine of one box's fork. Strike the fork with a rubber mallet; the sound should not die away quickly. If it does, mash the clay lumps flatter against the tines. How has the pitch of the fork changed?
5. Suggest an explanation for the difference in pitch.
6. Strike the forks of both boxes. Listen to the resulting sound and describe it.

7. Suggest an explanation for the sound you hear from the two tuning forks together.

8. Strike the fork of *one* of the boxes. Wait a few seconds and then gently hold the struck fork to stop its vibration. Now, feel the tines of the fork on the other box. What do you feel? How does it compare to part (a), when neither fork had clay on it? Suggest an explanation.

2. Singing tube

1. Hold the corrugated plastic tube by the flared end and swing it in a circle. Be sure not to hit anyone with the swinging tube! Do you hear a sound?

2. Change the speed of circling. Try to produce a different note. How many different notes can you make?

3. How are the different notes you produce related?

3. Boomwhackers

The “boomwhackers” are hollow plastic tubes of different lengths. Use them first with both ends uncapped. Practice making sound with the boomwhackers.

1. What action produces the loudest sound?

2. What action produces the clearest sound?

3. What is the difference in the sound produced by the tubes of different lengths?

4. We have a few black plastic caps that can be placed on the ends of the boomwhackers. How does capping one end of a tube affect the sound produced on the tube?

4. Resonance tubes and the speed of sound

Last week you found frequencies that sustained standing transverse waves in a given length of spring. Here, you will find column lengths that sustain standing longitudinal waves for given frequencies of sound.

You will place a source of sound (a tuning fork) at the opening of a tube and adjust the length of the tube to bring it in resonance with the sound. This means that the sound will form standing waves in the tube. In these standing waves, the water surface is at a node and the mouth of the tube is at an antinode (see the Figure). For each frequency of sound, you will find two successive resonant tube lengths. The difference between these tube lengths should be half the wavelength of the resonant sound wave.

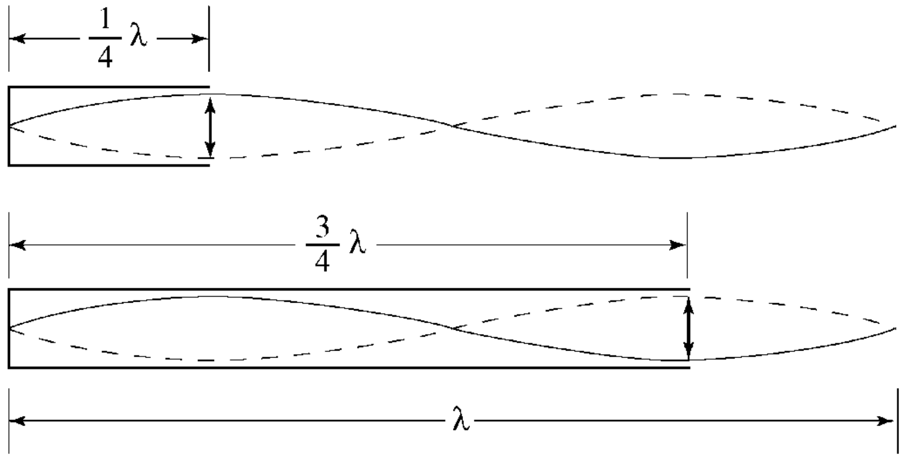

Figure. Resonance tubes and their standing waves. Standing waves have a node at the closed end of the tube and an antinode at the open end of the tube. **Note**: Sound waves are actually longitudinal, not transverse. The amplitudes drawn here represent how much the air molecules at the different positions vibrate, not the directions in which they move.

1. Raise the water reservoir or lower the tube so that the tube nearly fills with water.
2. Strike a tuning fork with the striker or other soft object. Hold the fork above the open end of the tube.
3. While holding the ringing fork over the tube, lower the water reservoir so that the water level in the tube drops. You should soon hear the sound intensify; this is the first resonant position of the tube. Record the position. Continue lowering the water level until you hear the sound intensify again at the second resonant position. If you do not hear the second resonance, your tuning fork probably makes sound with too long a wavelength. (Is the first resonant level more than one-third down the length of the tube? If it is, you need a higher-frequency tuning fork.)
4. Make sure that you are hearing the fundamental tone of the fork and not an overtone! To be sure you don't have an overtone, further lower the water level and check for lower-frequency resonances.
5. When you have found two resonances for the sound from the fundamental vibration of your tuning fork, measure their tube lengths. The tube length is the length of the air column in the tube when the tube is at resonance. It is the distance from the top of the inside tube to the water.
6. Repeat step 5 twice more with the same tuning fork, checking your previous measurements. Enter your data into the first three columns of the Table.
7. Repeat steps 1–6 using a second and third tuning fork, with different frequencies.

Table. Resonance Tube Lengths

Frequency (Hz)	1st Tube Length (m)	2nd Tube Length (m)	Difference (m)	Wavelength (m)	Average Wavelength (m)	Speed of Sound (m/s)

Data Workup

1. Compute the difference in the tube length between the first and second resonance positions for each row. Enter in the Table.
2. Compute the wavelength for each row from the difference. The difference between resonance positions is one-half the wavelength. (Thus, the wavelength is twice the difference between the two resonant lengths.) Also find the average wavelength for each frequency. Enter all these values in the Table.
3. Determine the speed of sound for each tuning fork using the frequency stamped on the tuning fork and the corresponding average wavelength. Frequency is given in units of hertz, Hz. A hertz is the inverse of a second: 1 Hz = 1/s.

   The speed of sound can be determined from the time it takes the wave to travel one wavelength. Recall that

   $$\text{speed} = \frac{\Delta \text{ distance}}{\Delta \text{ time}};$$

   here, Δ distance = wavelength, and Δ time = 1/frequency, so speed = wavelength · frequency. Enter these values also into the Table.

Lab Report

Complete all the observations and calculations. Answer all the questions in this sheet.