Sound Lab
BACKGROUND

A closed tube (one open end, one closed end) will resonate with a tuning fork when the frequency of the tube is related to that of the tuning fork. Since the closed end of the tube must be a node (N) and the open end an anti-node (A), the first position of resonance (ℓ) occurs when the tube is approximately one quarter (1/4) of a wavelength (λ). (See Figure 1). The next resonance position will occur when the length is three quarters (3/4) of a wavelength (that is 1/4 + 1/2 - see Figure 2), the next at five quarters (5/4) of a wavelength, and so on.

The differences of these positions will always be exactly one-half wavelength because they are the distances between two nodes. (NOTE: The first position is not exactly one quarter of a wavelength because the anti-node does not exist exactly at the end of the tube but rather slightly above it.) By recording the points at which the nodes occur, you can determine the length of the average half wavelength produced by the vibration of the tuning fork. This average number is then doubled, to determine the length of the average full wavelength produced by the tuning fork. This number is then multiplied <u>by the frequency number stamped on the tuning fork (Hz) to determine the velocity of a sound wave.</u>

The known velocity for sound waves in air at a temperature of 0° C is 331 m/s , or 33.1 m/s. For every 1° C increase in air temperature, sound travels 0.60 m faster per second. Thus, in a classroom with a temperature of 20° C (- 68° F), the velocity of sound should be approximately 343 m/s (0.60 m x 20° = 12 m/s 331 m/s). Also keep in mind that humidity affects the speed of sound.

If you have an unmarked tuning fork you can determine its frequency by measuring its wavelength on the apparatus and dividing this number by the value you calculated for velocity of sound.

In the following exercise you will use the Velocity of Sound apparatus to prove that the points of greatest resonance are indeed the points that are noted above. You will also use this data to determine the frequency of an unmarked tuning fork.

MATERIALS

1 – White PVC pipe (1" diameter -4 feet in length)
1 – Clear acetate tube (1-1/2" in diameter -4 foot length)
1 – solid stopper 1-1/2" diameter
1 – set of four tuning forks with known frequencies and one unknown
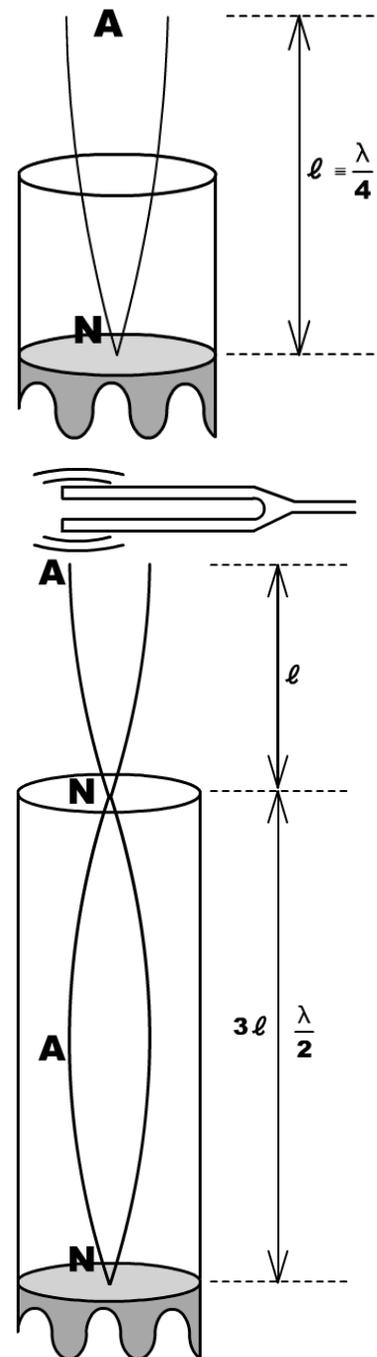
Sound Lab
PROCEDURE

1. Listen to you teacher for setting up the velocity of sound apparatus.

2. Fill the clear outer tube about two thirds full of water.

3. If necessary, insert the white plastic tube into the clear tube, making sure that the zero end of the metric scale on the white tube is at the top and the other end of the white tube is resting on the stopper at the bottom Now pour more water into the clear tube until it is full.

4. Obtain several tuning forks from your teacher. Note that one of the forks has a piece of tape on it to hide the frequency marking. SET THIS TUNING FORK ASIDE. **DO NOT REMOVE THE TAPE**.

5. From the remaining tuning forks, find the shortest tuning fork in the set. Record the frequency marking (Hz) for this fork (Fork' #1) in the appropriate space in Data Table 1, on the accompanying worksheet.

6. Use a rubber hammer or stopper to strike the tuning fork. (**Never** strike a tuning fork on a hard surface.) Now, hold the vibrating fork with the prongs in a vertical plane near the top of the white plastic tube, as shown in Figures 1 and 2.

Zero end of scale onthe white PVC tube goes at the top of the clear tube.

0

7. Slowly raise the white tube out of the water while you are holding the vibrating fork near the open end of the tube. At one point you will hear a sharp increase in the volume of the tone created by the tuning fork. This location indicates the position of a node in the sound wave. You can approximate where this point is by estimating the speed of sound and doing some calculations before listening.

8. Carefully adjust the height of the tube so that the sound is at maximum intensity. Use the scale on the side of the tube to assign a numerical value to the position of this node. (Remember to read this position as the amount of tube above the water level. The position of the top of the clear acetate tube has no significance.) In the appropriate space in Data Table I (Fork #1, Position #1), record the level of the water at the point where the sound is loudest.
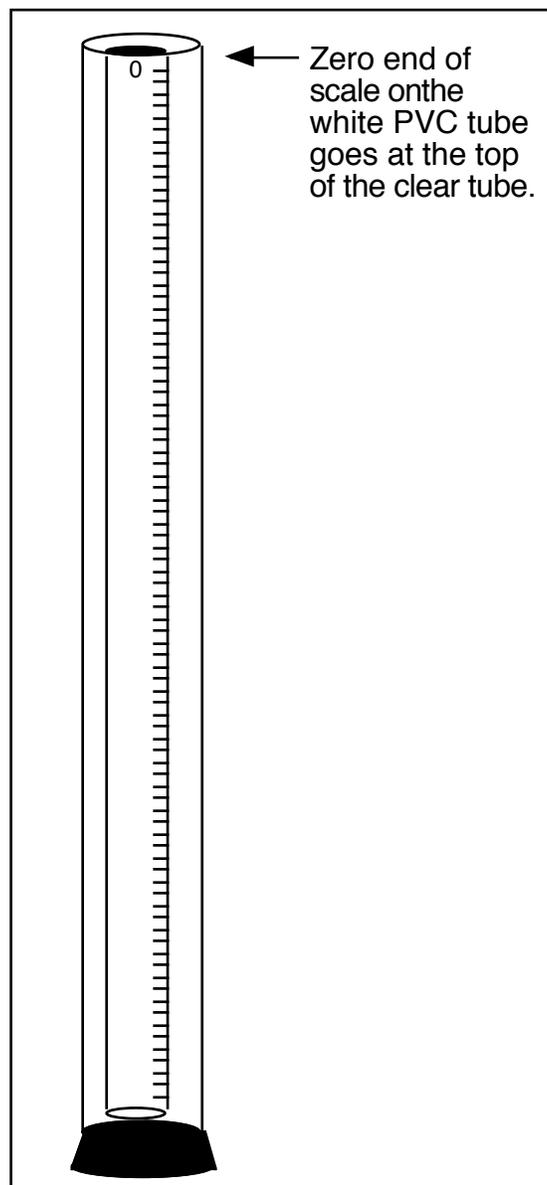
Sound Lab

9.   Carefully raise the white tube to a new position that is approximately three times the value of the first position. Adjust the tube around this point until a new position of resonance is found. Record this new height in the appropriate space (Position #2) of Data Table 1.

10.   Raise the tube to a new position that is approximately five times the value of the first position. Again, adjust the tube around this point until a new position of resonance is found. Record the number of this new height in the appropriate space (Position #3) of the Data Table.

11.   Repeat the previous step at least two more times, using positions that are seven times greater than the original position of greatest resonance, nine times greater, etc. until you exceed the length of the tube. Be sure to record your height reading for each node. **(NOTE: Depending on the frequency of the fork, you may only find one or two nodes. If you have a fork that produces more than five nodes, then stop at five.)**

12.   Now take the next shortest tuning fork (Fork #2) and repeat Steps 5-11. Be sure to record your data for the position of each node in the appropriate space in the Data Table.

13.   Repeat Steps 5-11 for each of the remaining marked tuning forks, in order of their length.

14.   Find the unmarked 'tuning fork that you set aside earlier. Or pick one up from the teacher. This is Fork #5. Repeat Steps 5-11 for this fork. Record all of your data for this fork in the appropriate spaces of the data table.

Sound Lab   Data Table

Fork #1 Frequency _____ Hz	Position Number					Name	$(f)(\text{Avg } \lambda/2) =$
	1st	2nd	3rd	4th	5th		
Node at (m) →							
Distance (in m) between nodes $(\lambda/2) \rightarrow$		2nd – 1st	3rd – 2nd	4th – 3rd	5th - 4th	Avg. $\lambda/2$	Calculate the speed of sound (m/s) ↓
Fork #1 Frequency _____ Hz	1st	2nd	3rd	4th	5th		$(f)(\text{Avg } \lambda/2) =$
Node at (m) →							
Distance (in m) between nodes $(\lambda/2) \rightarrow$		2nd – 1st	3rd – 2nd	4th – 3rd	5th - 4th	Avg. $\lambda/2$	Calculate the speed of sound (m/s) ↓
Fork #1 Frequency _____ Hz	1st	2nd	3rd	4th	5th		$(f)(\text{Avg } \lambda/2) =$
Node at (m) →							
Distance (in m) between nodes $(\lambda/2) \rightarrow$		2nd – 1st	3rd – 2nd	4th – 3rd	5th - 4th	Avg. $\lambda/2$	Calculate the speed of sound (m/s) ↓ ↓
Fork #1 Frequency _____ Hz	1st	2nd	3rd	4th	5th		$(f)(\text{Avg } \lambda/2) =$
Node at (m) →							
Distance (in m) between nodes $(\lambda/2) \rightarrow$		2nd – 1st	3rd – 2nd	4th – 3rd	5th - 4th	Avg. $\lambda/2$	Calculate the speed of sound (m/s) ↓
Fork #1 Frequency _____ Hz	1st	2nd	3rd	4th	5th		Avg. speed of sound from the values above (m/s)
Node at (m) →							
Distance (in m) between nodes $(\lambda/2) \rightarrow$		2nd – 1st	3rd – 2nd	4th – 3rd	5th - 4th	Avg. $\lambda/2$	Frequency of the unknown

Show how you calculated the unknown frequency in this space.