PHYSICS IN MOTION
gpb.org/physics-motion

Unit 6E
Standing Waves and Resonance
Resonance in a Closed Tube Lab TEACHER

In this activity, you will use resonance to determine the speed of sound in air by creating a standing wave in a closed-ended tube.

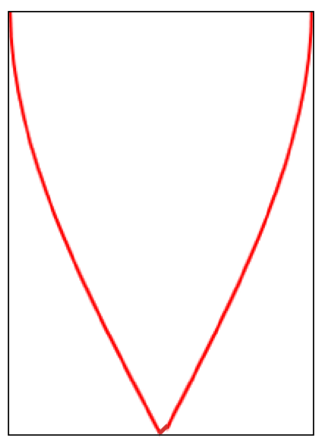
Materials:

- PVC pipe
- large graduated cylinder
- tuning forks
- ruler
- thermometer

A one-liter graduated cylinder or one-inch PVC pipe will work best for creating a water column. Tuning forks with frequencies between 380 and 520 Hz are also optimal.

Pre-Lab:

1. **Draw a diagram of the standing wave with the fundamental frequency in a closed-ended tube:**



2. **What is the equation for the wavelength of the standing wave in this tube?**

$$\lambda = \frac{4L}{n}$$

Procedure:

1. **Using temperature, determine the actual speed of sound in the classroom.**

temperature = 22 °C

$v_{sound} = 331\ \text{m/s} + (0.6\ \text{m/s°C})(temperature)$

$v_{sound} = 331\ \text{m/s} + (0.6\ \text{m/s°C})(22\ \text{°C})$

$v_{sound} = 344.2\ \text{m/s}$

questions continued on next page

Unit 6E
Standing Waves and Resonance
Resonance in a Closed Tube Lab TEACHER

Procedure:

2. Using different tuning forks, adjust the length of the air column in the PVC pipe in order for resonance to occur. Remember what must be on the open end of the tube!

   Note the frequency of the tuning fork and the length of the air column in the PVC pipe.
   Determine the speed of sound in air from these measurements.

Frequency (Hz)	Air Column Length (m)	Wavelength (m)	Speed of Sound in Air (m/s)
512	*0.17*	*0.68*	*348.2*
426	*0.19*	*0.76*	*323.8*
384	*0.22*	*0.88*	*337.9*

3. Calculate the average of your experimentally determined speed of sound values in the table above.

$$\textit{average} = 336.6\ \mathrm{m/s}$$

4. Find the percent error between your experimental value and the actual speed of sound in air.

$$\textit{percent error} = \frac{\text{actual value} - \text{experimental value}}{\text{actual value}} \times 100$$

$$\textit{percent error} = \frac{344.2\ \mathrm{m/s} - 336.6\ \mathrm{m/s}}{344.2\ \mathrm{m/s}} \times 100 = 2.2\%$$

Questions to consider:

1. Will the speed of sound be faster or slower when the temperature of the room is warmer?

   The warmer the air temperature, the faster the sound will travel.

2. How will the speed of sound change if a humidifier in the room increases the air humidity?

   The denser the air, the faster the sound will travel.

3. Which frequency tuning fork has a speed of sound value closest to the actual speed of sound? Explain why.

   Answers will vary depending on the data collected. Explanations should include how the wavelength in the tube is inversely related to the frequency.