Purpose: The purpose of this lab is to experimentally measure the speed of sound, $v$, using a resonance tube and then compare this result with the value found from the theoretical equation,

$$v = \sqrt{\frac{\gamma RT}{\mu}}$$

where $\gamma$ is the ratio of the specific heats, $R$ is the gas constant, $T$ is the temperature in Kelvins, and $\mu$ is the mass of air per mole.

Procedure: Slowly lowering the water level in the tube and listening for an increase in the sound volume of the tuning fork found resonance. When a resonance was found, the position of the node in the standing wave was noted. The wavelength of the standing wave was found to be twice the distance between two adjacent nodes. The speed of sound, $v$, was calculated from the wavelength $\lambda$, and the given frequency, $f$, of the tuning fork $v = f \lambda$.

Data:

Experimental Measurement of the speed of sound

<table>
<thead>
<tr>
<th>frequency (Hz)</th>
<th>$\lambda/4$ (cm)</th>
<th>$3\lambda/4$ (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1024</td>
<td>7.2</td>
<td>23.8</td>
</tr>
<tr>
<td>500</td>
<td>16.0</td>
<td>50.2</td>
</tr>
</tbody>
</table>

Sample calculation for 1024 Hz tuning fork

$$\lambda = 2(23.8 - 7.2) = 33.2\text{cm}$$

$$v = f \lambda$$

$$v = (1024\text{s}^{-1})(0.332\text{m})$$

$$v = 3.42 \times 10^2\text{m/s}$$
Note: All resonances were found to vary within ±2 mm around the reported nodes, giving wavelengths that were good to at most three significant figures. The tuning fork frequency was assumed to be accurate to the four significant figures, which leads to a value of the speed of sound good only to the three significant figures allowed from the wavelength measurements.

Theoretical calculation of the speed of sound
Room temperature was recorded at 21.0°C from the thermometer mounted on the barometer in the room. Calculations are shown below.

\[
v = \sqrt{\frac{\gamma RT}{\mu}}
\]

\[
v = \sqrt{\frac{7}{5} \times 8.31 \text{J/mol} \cdot 294.2 \text{K}}
\]

\[
v = \sqrt{\frac{29.0 \text{kg/mole}}{1000 \text{mole}}}
\]

\[
v = 3.44 \times 10^2 \text{(m/s)}
\]

**Table of Results:**

<table>
<thead>
<tr>
<th>(v) (m/s)</th>
<th>Theory</th>
<th>Experiment 1024 Hz</th>
<th>Experiment 500 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>(3.44 \times 10^2) (m/s)</td>
<td>3.40 \times 10^2) (m/s)</td>
<td>3.42 \times 10^2) (m/s)</td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion:** The purpose of this lab was to compare a theoretical prediction for the speed of sound with the results of measuring the speed of sound with a resonance tube. The theoretical prediction of the speed of sound agrees, 344 m/s, with experimentally obtained values, 340 m/s and 342 m/s, within the first two significant figures. There is some disagreement in the third significant figure where all of the results are uncertain. A more accurate value for the mass per mole of air is needed to gain accuracy in the theoretical prediction.

Because other experimenters in the lab were also finding resonance, it was sometimes difficult to tell if our apparatus was in resonance of another experimenters. The experimental results could be improved with more practice at using the apparatus in a noise free environment.