Purpose:
Use standing waves and the “wave equation” to determine the speed of electromagnetic and sound waves in air in our class room.

Procedures: Find a new partner. You and your partner will perform the sound measurements together, and write up the analysis. We will do the light measurement together as a class.

Speed of Sound Experiment

Equipment:
Large tube connected to water reservoir, meter stick, tuning forks, and your hearing (the detector).

Background Research:
In this experiment you will use the principle of resonance to determine the wavelength of a sound wave. If you know the frequency of a sound source you can then calculate the speed of sound using the “wave equation”:

\[
\text{Speed of Sound (or any wave) = frequency \times wavelength}
\]

You are familiar with the concept of resonance, but perhaps never knew what it was called. In class we talked about pumping energy into swinging your little brother or sister, making the swing go higher and higher. You may have heard a vase across the room rattle when just one note on a piano was played. The frequency of that note just happens to be the natural resonant frequency of the vase. By holding a vibrating tuning fork over an open tube containing some water and adjusting the length of the tube by adjusting the depth of the water, it is possible to get the air column in the tube to vibrate at its resonant frequency (which depends on its length \( l \)). This will be noticed because the sound becomes louder at the proper length. For a tube open at one end and closed by water at the other end, the first resonance occurs when the air column is about \( 1/4 \)th of the wavelength of the sound. This is because there has to be a wave node, or place where the air does not move, at the water (we are not pushing the air hard enough with the tuning fork to make the water move significantly), and a maximum in the motion of the air at the open end where it is being driven by the fork. So the sound wave has a crest at the open end and a node (zero crossing of the wave) at the water.

Procedure:
1. Start a new page in your lab book, with the title of the lab, your partner’s name, and the date. Draw the sound apparatus, as shown here, but with a drawing of the standing resonant sound wave in the air column. Make a table in your book with column headings: \( f, l, \lambda, c \).
2. Taking turns, one person strikes the tuning fork on the green rubber anvil and holds it in a horizontal position near the open tube. The partner raises and lowers the water reservoir until the sound for the fork is loudest, at which point the first person measures the distance \( l \) from the top of the tube to the water. Hunt around to be sure that this is the shortest distance that gives a “resonance”. You can check that it is correct by seeing if there is another loud sounding position when the column of air is \( 3l \) long. Write in your book why this is so. Draw a picture of the wave in this case.
3. Trading jobs, repeat the procedure in (1) with the other 2 tuning forks.
4. You have 3 results for the speed of sound in air. Average them and put the answer as an equation in a box in your book.
Analysis
1. The accepted speed of sound is 332 m/s at 0º C, and increases 0.6 m/s for each Celsius degree above zero. Use a thermometer (on the front bench) to find the temperature of the room in º C. What is the accepted value for the speed of sound in your classroom?
2. How does your calculation for the speed of sound compare with the accepted value?

Speed of Light or any Electromagnetic Wave

Equipment:
Microwave oven, glass baking dish, miniature marshmallows, ruler.

Procedure
1. Place the marshmallows in the dish so that one layer covers the bottom, but the marshmallows do not touch. Place dish in oven without titling and close door.
2. Run oven for a short time (10 secs) watching for some of the marshmallows to melt. If you do it just right, a few of them will momentarily expand and soften. Note where these are.
3. Measure the shortest distance between these melted areas, writing them in your book. You might measure and then reheat a little to see more melting. Perhaps then the measurements will be more clear.
4. Average all these measurements, putting this number in a box in your book.
5. Find the frequency of the microwaves inside the oven, and write this in a box in your book.

Analysis
Use the two numbers you have just obtained to calculate the speed of light. Compare it to the accepted value in your book. Congratulations, you have just measured your second fundamental constant!