Lab 2: Speed of Sound Physics 1320 Profs. Tunks / Olness

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A Historical Introduction:

We are going to measure the speed of sound. Our method will be based upon a historic experiment performed by Galileo that attempted (and failed) to measure the speed of light.

On a dark night, Galileo sent his assistant to a distant hill with a lantern. When Galileo flashed his lantern, the assistant was instructed to also flash his lantern. By measuring the time interval between when Galileo initially flashed his lantern and when he saw the light return from the assistant's lantern, he could determine the amount of time it took the light to travel to the distant hill and back.

Let me demonstrate this point with some numbers. The numbers I'll use here are fake, but they will serve to illustrate the point, and keep the math simple. Suppose Galileo and his assistant are 5 miles apart, and the time delay Galileo measured was 2 second. Naively, one might deduce that since the light took 2 seconds to travel the 10 mile trip (5 miles each way), that the speed of light is 5 miles/sec. <u>This deduction is incorrect!!!</u>

Fortunately, Galileo realized that part of the 2 second time delay was due to the reaction time of his assistant, and although he paid top-dollar (or was it top-lire?) for his assistant, he must find another means of eliminating this error.

Therefore, Galileo performed a <u>second</u> measurement and sent his assistant to a second hill 10 miles away. This time he also measured a time delay of 2 seconds. He therefore (correctly) deduced that the difference between the two measurements (2sec - 2sec = 0sec) represented the time it took light to travel the round trip from the 1st hill to the 2nd hill, and the remaining time (2sec) represented the reaction time of his assistant.

<u>Conclusion:</u> Within the accuracy that Galileo could measure, all the time delay was due to the reaction time of his assistant, and the speed of light he measured was so fast that it took a negligible time to cover the distance.

<u>Moral:</u> Because Galileo was no slouch, he was able to use the two data points to remove the reaction time of his assistant from the experiment.

<u>EXPERIMENT:</u>

We are going to re-enact Galileo's famous experiment, but to measure the speed of sound rather than light. Since sound is a bit slower, this technique should yield a reasonable answer.

<u>Step 1: Time Measurement:</u>

Measure the time delay that it takes sound to travel 2 different distances. For each distance, take 5 measurements and average them to minimize random error.

For each of the two distances, fill in the following tables. We will refer to these two average times as $\{t_1,t_2\}$.

DISTANCE #1

Measurement	Time (sec)
1	
2	
3	
4	
5	
AVERAGE=t_1	

DISTANCE #2

Measurement	Time (sec)
1	
2	
3	
4	
5	
AVERAGE=t_2	

Step 2: Distance Measurement:
Measure the distance from the sound source to the point of measurement. We will refer to these two times as $\{d_1,d_2\}$.

We will measure these distances by **paces**. We will calibrate our paces using the fact that the distance from the flagpole to the steps of Dallas Hall (the main steps) is 675 feet = 206 meters. Fill in the following table:

Measurement	# of Steps	Remark
N_0		Dallas Hall to Flagpole
N_1		Sound Source to Point #1
N_2		Sound Source to Point #2

We then compute the distances as follows:

d_1= (206 meters) (N_1/N_0) =

d_2= (206 meters) (N_2/N_0) =

Step 3: Plot the Data:
Make a plot of your data on graph paper. Put TIME on the horizontal (x-axis), and DISTANCE on the vertical (y-axis). Draw a straight line through these points, and continue this through the x-axis.

Step 4: Calculate the Slope:
The slope of the line on this plot yields the speed of sound. We compute this as follows:

$v = (\Delta d/\Delta t) = (d_2-d_1)/(t_2-t_1)$

Step 5: Calculate a prediction for the speed of sound. :

Using the measurement of the outside temperature, compute a theoretical value speed of sound as given by the formula: v= 332 m/s (@ 0°C)± 0.6 m/s /°C

Step 6: Conclusions :

Compare the theoretical value of Step 5 with that of Step 4. Comment.

QUESTIONS:

- On your plot, you should find that when the distance is zero, the time is NOT zero. What does this mean? Obviously it takes sound 0 sec to travel 0 meters. What does this time represent?
- How will your measurement be affected by i) wind? ii) temperature? iii) speed of light?
- What other uncertainties are involved here that we have not addressed.
- In this experiment, we had to remove the human reaction time. Can you design a simpler experiment where this would not be necessary.