Student

Tutor

Course

Date

Speed of sound

Purpose

The experiment aims at measuring the speed of sound in air. The experiment requires us to measure the time taken for a sound pulse to travel a given distance. To accurately deduce the speed of sound we will plot a graph of the distance traveled versus the time taken, and finally, obtain the slope.

Theory

A sound is a wave that is propagated through pressure change. The object generating the sound will push air resulting in the increase in pressure in front of it. The cycle will create a movement of high and low regions in the wave creating sound.

To determine the speed of an object its position is measured as a function of time. Holding speed constant the position of an object will always change linearly will increase in time. From the relationship

$$Speed = \frac{Distance\ traveled}{Time\ elasped}$$

We obtain

$$x = vt + x_0$$

Where

x_0 = initial position of the object.

From the linear equation above we realize the slope of the graph plotted will give the speed of the object.

The movement of sound in air is dependent on the density and temperature of the air of propagation. Using sound at 20Hz frequency, the temperature dependence can be computed from the equation

$$v = 332.12\sqrt{1 + \frac{T}{273.15}} \text{ (m/sec)}$$

Where

T = temperature in degrees,

Theoretically at normal atmospheric pressure, with 50% relative humidity sound moves at an average speed of 345.25 m/s. So as to be able to carry out the experiment we measure the time taken to travel the given distance.

Apparatus and procedure

Lucite tube: is fitted with two speakers, where one speaker is fitted at the end of the tube while the other is movable inside the tube. The distance between the two speakers can be measured using a metric tape used to calibrate the inside of the tube. The first speaker is the transmitter while the second is the detector of the sound pulse.

Electric pulse generator: will provide the voltage pulse that will generate the sound to be transmitted at constant intervals of time. The time between the application of the voltage and the appearance of the pulse at the receiving speaker will be equal to the time it takes for the sound pulse to travel between the two speakers.

Oscilloscope: the electron beam can be used to measure the various speed when swept horizontally. The time between the start of the horizontal motion of the electron beam and the start of the vertical deflection is equal to the time of travel of the sound pulse between the two speakers.

Procedure

1. Move the second speaker until the first large sharp peak of the voltage trace displayed on the oscilloscope screen coincides with the 0.5 ms vertical line corresponding to the time, *t*, equal to 0.5 ms. Measure and record the position, *x*, of the second speaker in a table consisting of two columns, one for the time *t*, and the other for the position, *x*.
2. Repeat step 1 above for additional values of *t* [1, 1.5, 2, 2.5, and 3 ms] corresponding to other vertical lines on the oscilloscope screen. Continue to use table one for this data.
3. Plot a graph of *x* (cm) versus *t* (ms). In class, you plot this graph using Excel.
4. Since the speed of sound is constant, the graph of *x* vs. *t* should be a straight line. Using two dimensional statistics, linear regression, $v_{exp.}$

Data

time t (ms)	position X (cm)

0.5	21.5
1	38.2
1.5	55.7
2	73.52
2.5	89.8
3	107.5

Calculation and analysis

Slope of the graph = $\frac{\square ?}{\square ?}$

V_{exp} = 34.43543 cm/ms

Intercept = 4.108

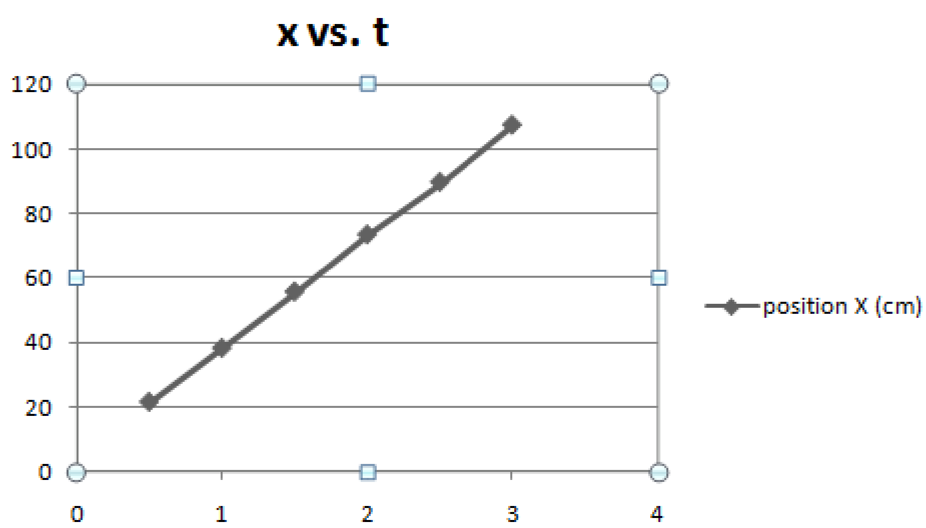
linear correlation coefficient, R^2 = 0.999883

S_y = 0.390355

S_{slope} = 0.186625

$S_{intercept}$ = 0.363401

Graph



Questions

1. The straight line indicates that the speed of sound is uniform throughout the duration of propagation.

2. The resulting graph would have been a curve as the acceleration would be a non-zero hence constantly varying.
3. Distance for t= 0.5 ms

   Distance = [illegible]

   = 34.43543 cm/ms x 0.5

   =17.2177 cm

4. Distance travelled by light

   Distance = [illegible]

   = (3.00 x 10^8 m/s.) x(0.5 x 10^{-3})

   =150000 x 1609.34^{-1}

   = 93.2059 miles

5. a) The closeness of the linear correlation coefficient, R^2 shows that the two variables are linearly related.

   b) Obtaining the distance moved by the pulse during each time interval.

Conclusion

Finally, it is evident from the experiment that the value obtained is close to the theoretical value. It can also be reasonably be deduced that the parameters time and distance are linearly related.