Between-Labs Assignment
(due by Wed/Thu Lab)

Submit answers to Slides 34, 35, 36 and 37 on Gradescope.

Distance vs delay

Distance (cm)	Delay (microsecond, mean ± stddev)
15.2	955 ± 12.1
30.5	1852 ± 6.2
45.7	2751.9 ± 11.3
61.0	3615 ± 9.7
76.2	4473.4 ± 16.1
91.4	5317.8 ± 12.6

Change the distance values on the left column based on the reference lengths you used. Use microsecond or seconds for time delay.

Plot of distance vs delay

➤ **Plot time-of-flight delay (y-axis) vs reference length (x-axis). Jupyter notebook**
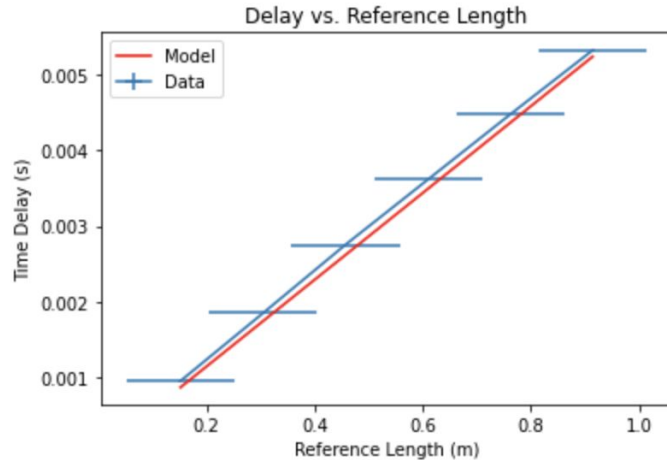
Error: 4.27 m/s

Speed of sound

➤ **What speed of sound did you find through your analysis?**
  ○ **349.3 m/s**
➤ **What is the temperature in your room? 72° F**
➤ **What is a standard speed of sound from a textbook given the measured room temperature? 344.44 m/s**
➤ **What may contribute to any differences between the speed of sound you found and a textbook speed of sound?**
  ○ **Human error in measurement, extra delay generated by the devices used to record data**

Acceleration

Suppose you use a numpy polyfit function to fit the position vs time of an object.

results = np.polyfit(time, position, 2)

Given the following properties of motion, fill in the elements of the "results" array (assuming velocity and acceleration are in the same direction)?

- Initial position = 1 meter
- Initial velocity = 0.5 m/s
- Acceleration = 9.8 m/s

results = [4.9, 0.5, 1]

Error propogation

- **The covariance matrix from np.polyfit provides the variance in the slope and the intercept.**
- **If the speed of sound was 1/slope, then the error in speed of sound is obtained from error in the slope as follows.**

$$\frac{\sigma(Speed\ of\ sound)}{|Speed\ of\ sound|} = \frac{\sigma(Slope)}{|Slope|}$$

σ is the standard deviation and it is the square root of variance. The standard deviation of the speed of sound is the required error. (The denominators must hold absolute values)

Reference (page 2) : http://ipl.physics.harvard.edu/wp-uploads/2013/03/PS3_Error_Propagation_sp13.pdf