SOUND ASLEEP

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INTRODUCTION

- Human beings are sensitive to sound
- Sounds come from different sources
- Some sounds desirable at higher levels
  - e.g. Vocal or instrumental music
  - May need to be amplified
- Some other sounds not desirable
  - e.g. Car exhaust noise, Industrial noise
  - May need to be attenuated
- Many of these sounds propagate through tubes

QUESTION

What is the effect of the length of a hollow tube on the amplitude of sound propagating through it?

HYPOTHESIS

If

length of tube is gradually reduced,

then

sound amplitude oscillates periodically

VARIABLES

IV: Length of tube

DV: Amplitude of sound at end of tube

Control: Amplitude with no tube

CONSTANTS

Setting of experiment (room)

Ambient sound level in setting

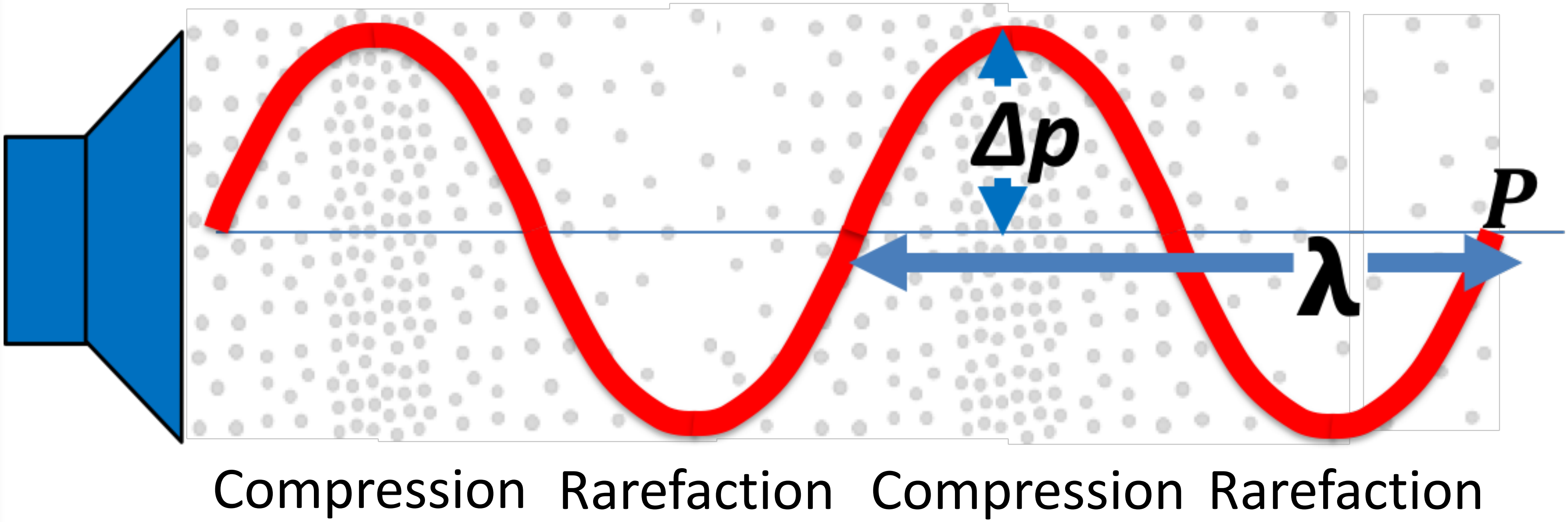
Material used for tube (cardboard)

Device used to produce sound

Device used to measure sound

RESEARCH

Properties of a sound wave



λ - wavelength *f* – frequency $v_s = \lambda f$ = 343 m/s

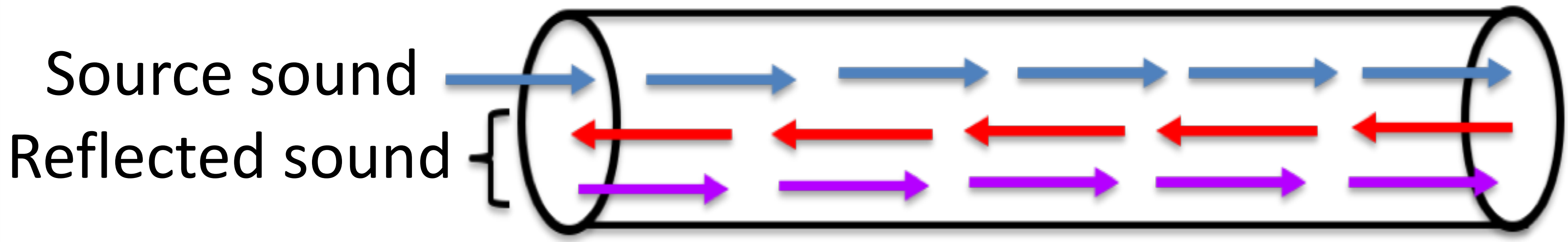
P – ambient pressure Δp – max pressure change

Intensity, $I \propto (\Delta p)^2$ $I_0 = 10^{-12}\ W/m^2$

Sound Level (or amplitude) $= \mathbf{10\ log}\left(\frac{I}{I_0}\right)$ **dB**

RESEARCH

Sound reflection in open-ended tube

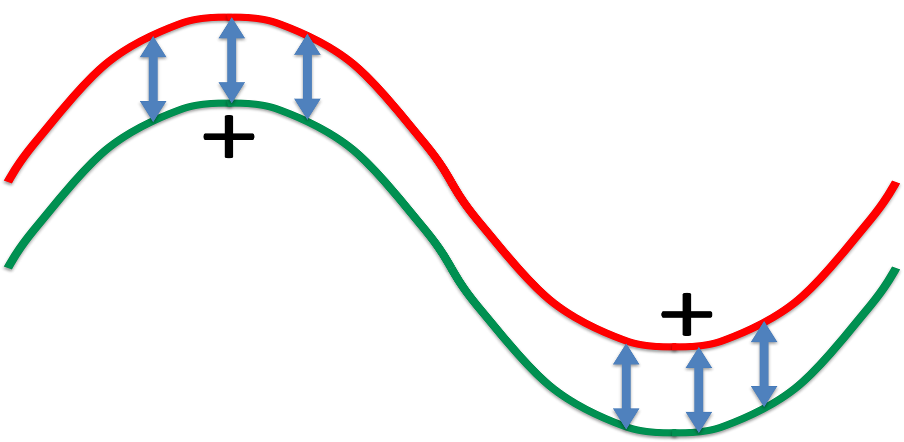


Open ends of tube reflect sound waves

Sound interference

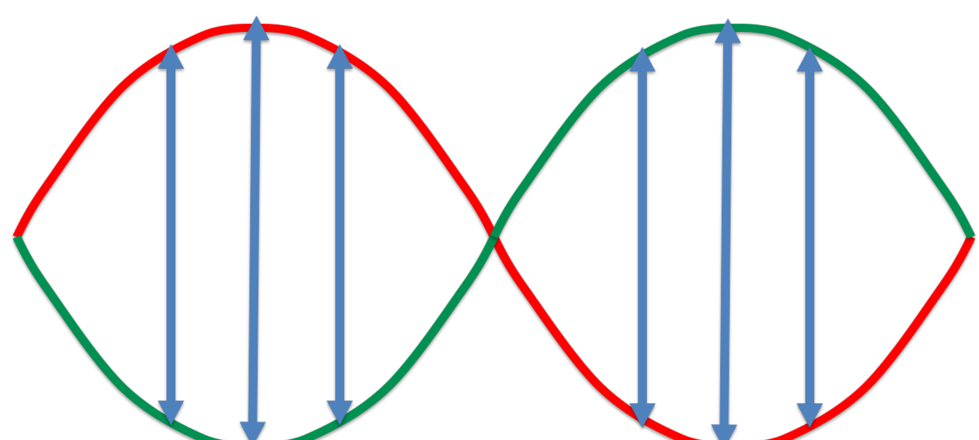
Waves Add ⇒ More sound

Constructive Interference

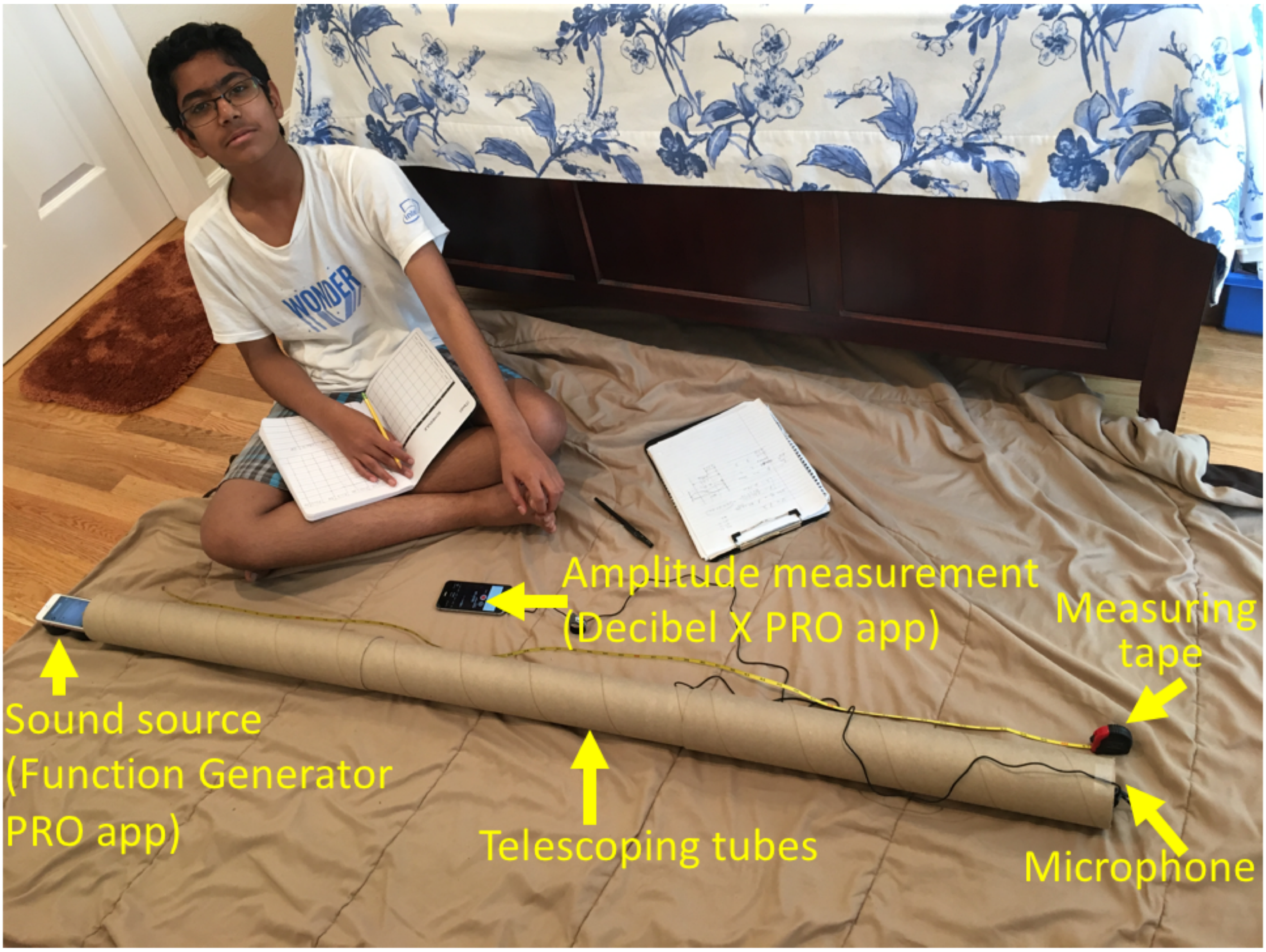


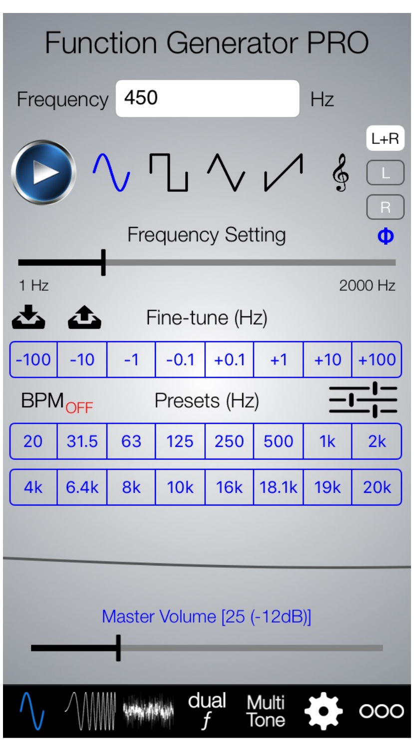
Waves Subtract ⇒ Less sound

Destructive Interference

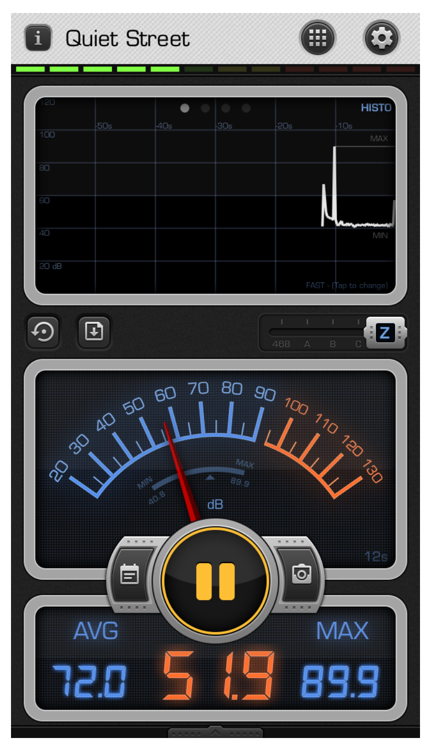


SETUP





App in Phone 1
for sound generation



App in Phone 2
for amplitude measurement

MATERIALS

- Two telescoping hollow cardboard tubes
  - Length varied between 0.53m to 1.07m
- iPhone 1 with Function Generator PRO iOS app
  - Generate frequencies 20Hz - 20,000 Hz
- iPhone 2 with Decibel X PRO iOS app
  - Measures sound amplitude in decibels
- Tape measure to measure length of tube
- Lavalier microphone to capture sound
- Pencil and paper to record measurements

PROCEDURE

1. Set Function Generator app in iPhone 1 to 700Hz
2. Connect microphone to iPhone 2
3. Set iPhone 1 at sound source end of the tube
4. Position the microphone in front of iPhone 1
5. Measure sound amplitude at source with iPhone 2
6. Extend the telescoping tube to length of 1m
7. Tape microphone to the other end of the tube
8. Position microphone at center of tube opening
9. Reduce tube length by collapsing the tubes and stop when sound amplitude reaches a maximum or a minimum
10. Measure and record the length of tube
11. Record sound amplitude at end of tube
12. Remove tube and record sound amplitude at same location
13. Repeat steps 8-12 by decreasing tube length until all maximums and minimums are recorded
14. Repeat steps 3-13 for iPhone 1 source frequency set at 1200Hz, 1700Hz, 2200Hz and 2700Hz
15. Repeat each measurement above 3 times for trials

DATA

Source frequency: 700Hz

Amplitude setting	Mean tube length (cm)	Mean Amplitude (dB)	
		With tube (expt.)	Without tube (control)
1st min	104.56	94.4	66.1
1st max	91.86	104.83	73.9
2nd min	81.28	94.73	77.67
2nd max	68.26	105.27	73.03

Amplitude at source: 97.1 dB

Source frequency: 1200Hz

Amplitude setting	Mean tube length (cm)	Mean amplitude (dB)	
		With tube (expt.)	Without tube (control)
1st min	102.34	94.53	67.8
1st max	95.36	101.3	68.33
2nd min	88.16	94.97	69.50
2nd max	80.65	100.97	62.83
3rd min	72.92	94.47	65.9
3rd max	67.10	100.73	64.43
4th min	58.86	94.37	71.13

Amplitude at source: 94.07 dB

Source frequency: 1700Hz

Amplitude setting	Mean tube length (cm)	Mean amplitude (dB)	
		With tube (expt.)	Without tube (control)
1st min	101.60	93.40	59.6
1st max	96.84	97.40	58.37
2nd min	91.97	93.47	66.50
2nd max	86.57	97.90	68.63
3rd min	81.28	94.03	68.63
3rd max	76.41	97.93	69.90
4th min	71.12	93.93	65.6

Amplitude at source: 93.93 dB

Source frequency: 2200Hz

Amplitude setting	Mean tube length (cm)	Mean amplitude (dB)	
		With tube (expt.)	Without tube (control)
1st max	105.20	100.17	67.50
1st min	101.71	97.67	69.43
2nd max	96.94	100.43	58.70
2nd min	93.03	97.87	66.10
3rd max	89.75	100.5	59.57
3rd min	85.41	98.03	70.33
4th max	81.70	100.4	71.50
4th min	77.79	97.83	66.57

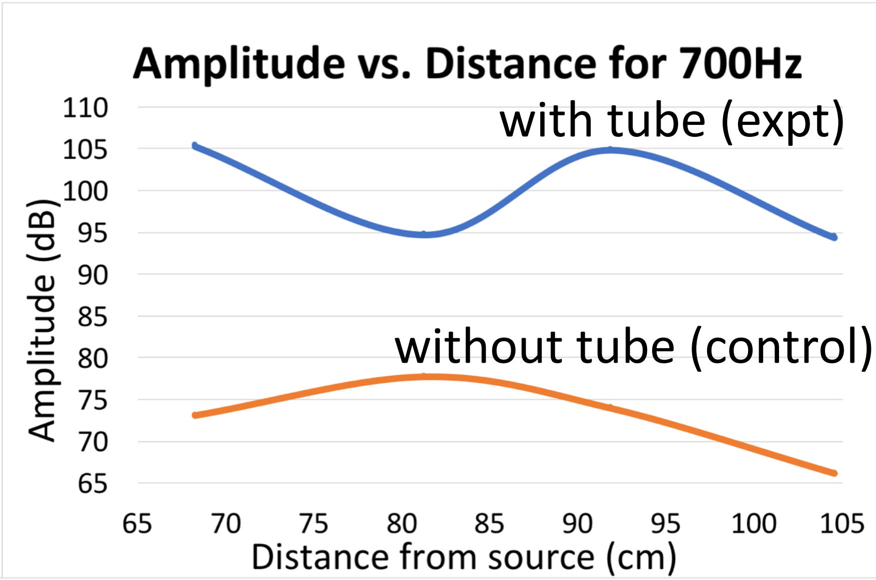
Amplitude at source: 96.83 dB

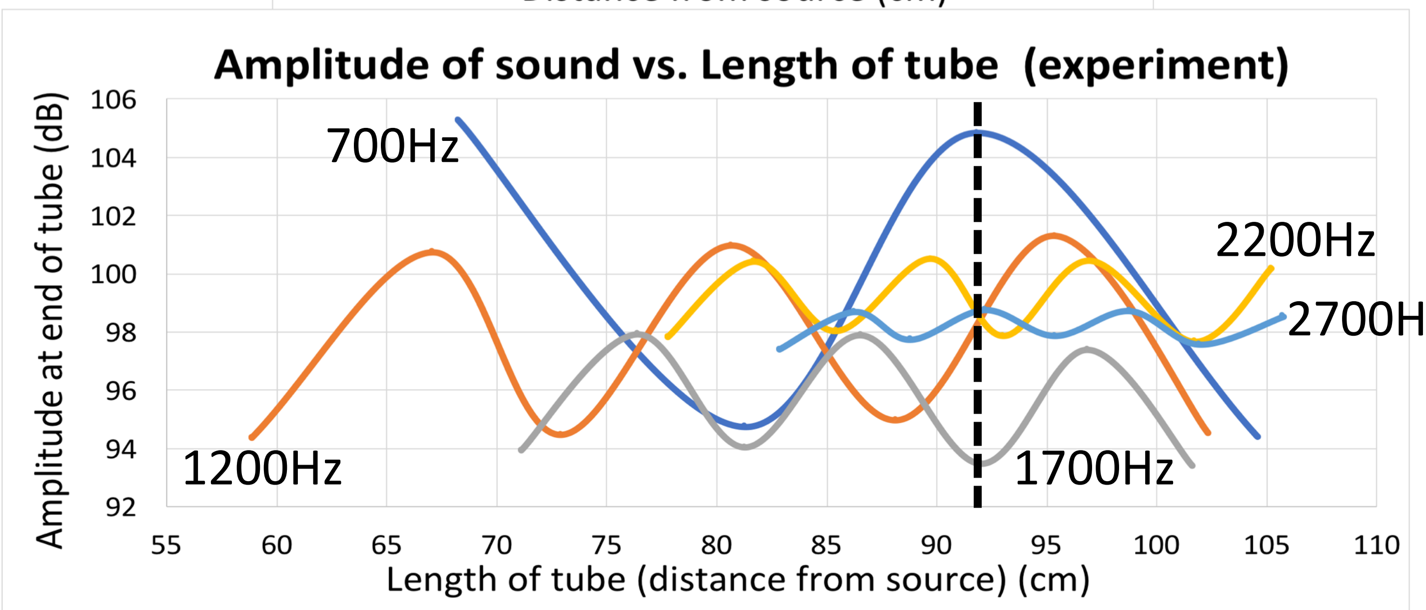
Source frequency: 2700Hz

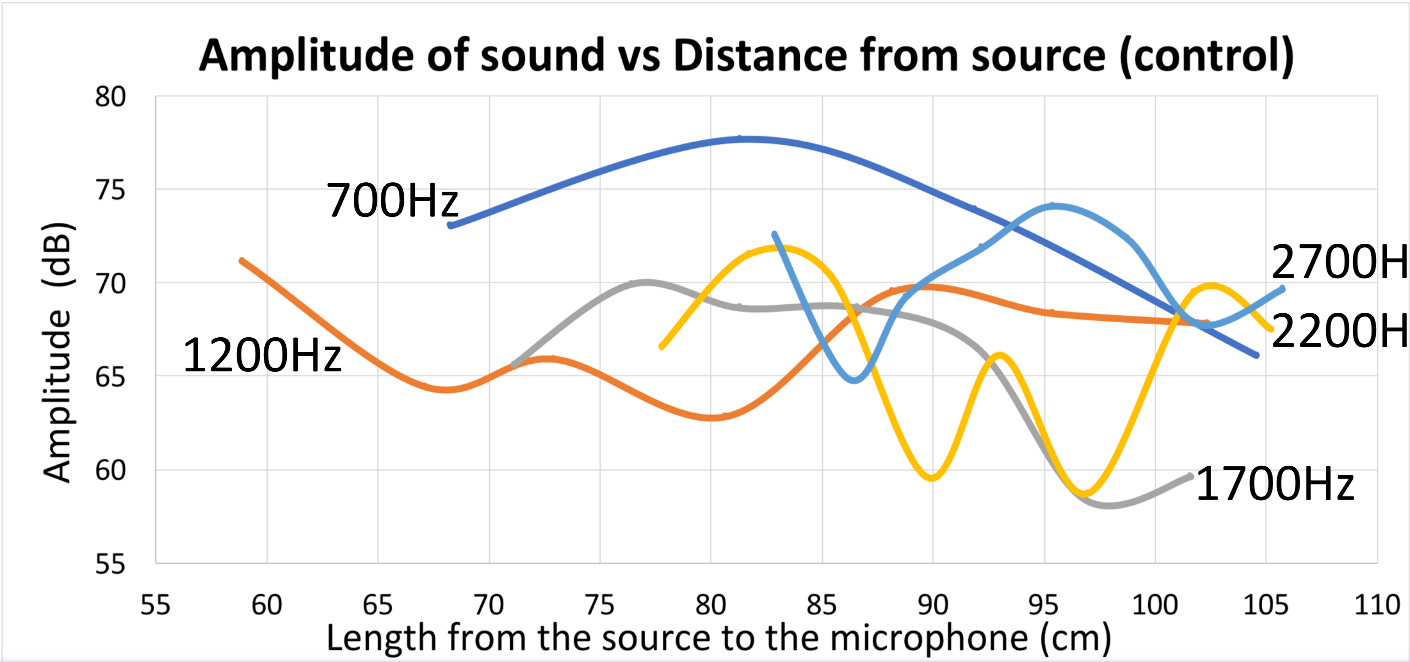
Amplitude setting	Mean tube length (cm)	Mean amplitude (dB)	
		With tube (expt.)	Without tube (control)
1st max	105.73	98.53	69.63
1st min	101.92	97.57	67.77
2nd max	98.74	98.73	72.37
2nd min	95.36	97.87	74.10
3rd max	92.18	98.77	71.83
3rd min	88.79	97.73	69.23
4th max	86.25	98.70	64.8
4th min	82.87	97.40	72.57

Amplitude at source: 100.17 dB

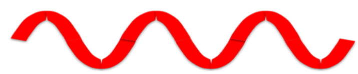
RESULTS


Amplitude vs. Distance for 700Hz
with tube (expt)
without tube (control)
Amplitude (dB)
110
105
100
95
90
85
80
75
70
65
65 70 75 80 85 90 95 100 105
Distance from source (cm)


Amplitude of sound vs. Length of tube (experiment)
Amplitude at end of tube (dB)
106
104
102
100
98
96
94
92
700Hz
2200Hz
2700Hz
1200Hz
1700Hz
55 60 65 70 75 80 85 90 95 100 105 110
Length of tube (distance from source) (cm)


Amplitude of sound vs Distance from source (control)
Amplitude (dB)
80
75
70
65
60
55
700Hz
2700Hz
2200Hz
1200Hz
1700Hz
55 60 65 70 75 80 85 90 95 100 105 110
Length from the source to the microphone (cm)

CONCLUSION

- Results show that hypothesis is correct
- For a fixed source frequency,
  - Tube length ↓ ⇒ amplitude 
  - Differences in tube length between consecutive extrema remain the same
  - Max and min amplitudes remain almost constant
- Frequency ↑

  ⇒ Difference in tube lengths between consecutive extrema is lower

  ⇒ Difference between max and min amplitudes decreases
- Amplitudes with tube are higher than that without the tube

FUTURE RESEARCH

- Explore effect of different **tube shapes** (conical, square cylindrical) on amplitude
- Explore effect of different **tube materials** (metal, foam) on amplitude
- Investigate addition of **closed end tube attachments** to muffle sound
- Use **additional sound sources** to cancel/amplify sound from main source

SELECTED REFERENCES

1. Sound Wave Interference. (n.d.). Retrieved October 23, 2018 from https://www.nde-ed.org/EducationResources/HighSchool/Sound/interference.htm
2. Woodford, C. (2018, February 20). Sound – The science of waves, how they travel, how we use them. Retrieved October 23, 2018 from https://www.explainthatstuff.com/sound.html
3. Syllabus, Fall 2008. (n.d.). Retrieved from http://www.physics.indiana.edu/~courses/p109/P109fa08/