Date of Lab 4/30/2018 Date of Submission 5/7/2018

Laboratory Report

Title Resonance in a Pipe

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Summary

In this lab, I was able to observe the resonance phenomenon and also actually make the first and second resonance of different tune forks.
First we calculated the theoretical values of each tune fork. Then, using the water column, we measured the experimental values of the first and second resonance (when the sound is maximum), and found out the experimental frequency, wavelength and the location of antinode in the open end.
Also we found the theoretical and experimental values of the third resonance. As a result, the errors were small which means we got good results in this lab experiment.

· Meet a deadline · Write logically · Write clearly · Write with your own words

Teacher's Comments

A clear and beautiful report.

1	2	3	4	5	6	7	8	9
Due	Summary	Intro.	Method.	Results	Table/Fig.	Discussion	Clearness	General
+	+				+++	+	+	++

* Use this form as a cover sheet.
* Submit your reports by the seventh day after your lab.

Introduction

Objective

Observe the resonance phenomenon and find the first and second resonance using different tune forks and a water column.

Calculate the theoretical and experimental values and compare to see how much difference it has. Also, if possible find the value of the third resonance of both the theoretical and experimental values.

Theory

- Resonance Phenomenon: It occurs when the frequency of the tune fork matches the air frequency. When the two frequencies match the sound will increase.
- Speed of Sound: $V=331.5+0.6t$ (m/s) ・・・(#1)
  ※t= temperature of the room
- Wavelength of Theoretical Value: $\lambda_{theo}=V/f$ (cm) ・・・(#2)
- Length of Air Column in Resonance:
  $A_{theo} = \lambda_{theo}/4$ (cm) ・・・(#3)
  $B_{theo} = 3\lambda_{theo}/4$ (cm) ・・・(#4)
- Wavelength of Experimental Value: $\lambda_{exp} = 2(B_{exp}-A_{exp})$ (cm) ・・・(#5)
- Frequency of Experimental Value: $f_{exp} = V/\lambda_{exp}$ (Hz) ・・・(#6)
  ※ λ_{exp} should be changed from cm to m and then calculated
- Location of Antinode at the open end:
  $\Delta A = A_{theo}-A_{exp}$ (cm) ・・・(#7)
  $\Delta B = B_{theo}-B_{exp}$ (cm) ・・・(#8)
- Theoretical Third Resonance: $C_{theo} = \lambda_{theo}+\lambda_{theo}/4 = 5/4\,\lambda_{theo}$ (cm) ・・・(#9)
- Experimental Third Resonance: C_{exp} (cm)
  ※Measurements should be done if C_{theo} is shorter than the tube length.

Experimental

Materials

- Air
- Water
- Water column (with a rubber tube and cup connected to the column)

- Tune Forks (C, B, A, G, F, E, D, C)
- Mallet
- Thermometer

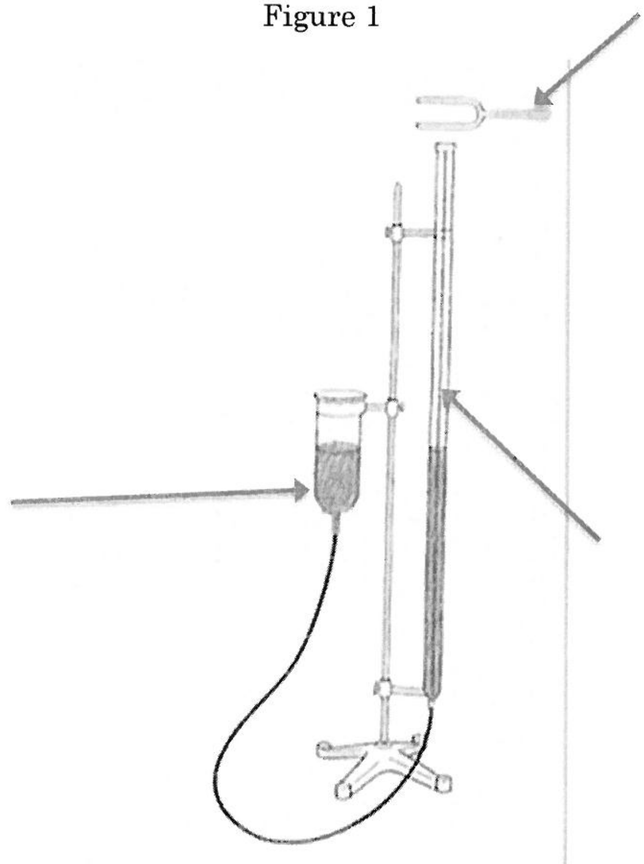
Methods

1. Measure the room temperature using the thermometer and calculate the speed of sound using equation #1.
2. Calculate the theoretical values of the wavelength and the length of air column in resonance using equations #2, #3 and #4.
3. Let the surface level of water move to the area of A_{theo} or B_{theo}. Then observe and measure the experimental values of the first and second resonance between each tune fork and the water column.
4. Calculate the experimental values of the wavelength, frequency, and location of antinode at the open end using equations #5, #6, #7 and #8.
5. Find the theoretical value of the third resonance using equation #9.
6. Measure the experimental value of the third resonance if possible. Or use equation #10 to find the third resonance.

Experimental Design

See below.

Figure 1



Results

The room temperature was 25°C. So the speed of sound was

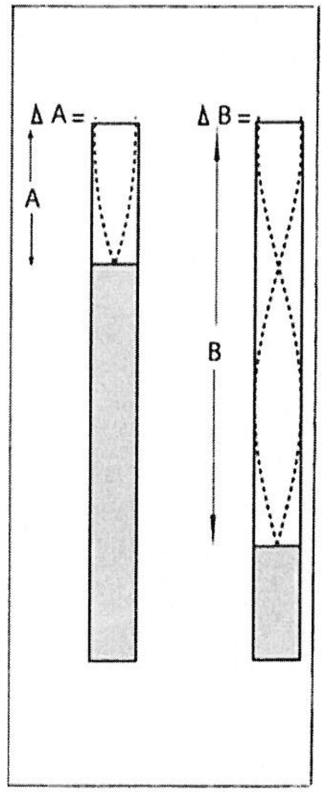
V =331.5+0.6×25=346.5 m/s.

Calculated Values and Measured Results of the Experiment

Table 1

Tune Fork		Theoretical (theo)			Experimental (Exp)						
	Frequency f (Hz)	λ (cm)	A (cm)	B (cm)	A_{exp} (cm)	B_{exp} (cm)	C_{theo}/C_{exp} (cm)	λ_{exp} (cm)	f_{exp} (Hz)	ΔA (cm)	ΔB (cm)
C Do	512	67.7	16.9	50.8	15.9	50.0	84.6/×	68.2	508	1.0	0.8
B Ti	480	72.2	18.0	54.1	16.8	53.5	90.2/×	73.4	472	1.2	0.6
A La	426.7	81.2	20.3	60.9	18.7	59.7	101.5/×	82.0	422	1.6	1.2
G So	384	90.2	22.6	67.7	21.5	66.5	112.8/×	90.0	385	1.1	1.2
F Fa	341.3	102	25.5	76.5	24.0	75.2	127.5/×	~~102.4~~ 102	338	1.5	1.3
E Mi	320	108	27.0	81.0	26.0		135.0/ ×			1.0	
D Re	288	120	30.0	90.0	28.8		150.0/ ×			1.2	
C Do	256	135	33.8	101.3	32.3		168.8/ ×			1.5	

※Discription of ΔA and ΔB (Figure 2)



Errors (Error = $\frac{Theoretical-Experimental}{Theoretical} \times \mathbf{100}$)

Table 2

	λ_{theo}& λ_{exp}	A_{theo}&A_{exp}	B_{theo}&B_{exp}	f_{theo}&f_{exp}
C/Do	−0.7%	5.9%	1.6%	0.8%
B/Ti	−1.7%	6.7%	1.1%	1.7%
A/La	−1.0%	7.9%	2.0%	1.1%
G/So	0.2%	4.8%	1.8%	−0.3%
F/Fa	−0.4%	5.8%	1.7%	1.0%
E/Mi		3.7%		
D/Re		4.0%		
C/Do		4.4%		

Discussion

As we can see the results in Table 1 and the errors in Table 2, we were able to measure the first and second resonance and observe the resonance phenomenon. We can say that the experiment went quite well because we only had errors of less than 8%. When we measured the first and second resonance, we tried to determine where the sound is maximum, which from the theory, is where the frequency of the tune fork and the natural frequency of air matches. We weren't able to measure the second resonance of E (320Hz), D (288hz), and C (256Hz) because the water column was too short to measure.

Conclusion

In conclusion, when the frequency of the tune fork matches the air frequency, the volume of the sound will increase and that point will be the value of the first or second resonance. Also we were able to know that it is easy to find and see the resonance phenomenon or the first and second resonance of different tune forks by using a simple materials.

Opinions

From this experiment I was able to see the resonance phenomenon. I thought this experiment was the most interesting one from the labs I have done in the previous quarters. But at the same time I found this experiment was a bit difficult because it was challenging to adjust the water surface level in the water column and placing the tune fork in the same position above the water column. If the position changes, the results might change. The results might also differ if there is a difference in how hard we hit the tune fork each time we do the experiment so I tried very careful when doing it. Also as it is mentioned in the discussion, the water column was too short that we couldn't measure the second resonance of E, D and C. So I thought it is better to change to a longer water column when doing this experiment.

Resources

- Lab Report of Shutomo Iwai(2017)

11-0 Kiku Kogure

PhysicsLab-051	Resonance in a Pipe

1. Preparation	Air/water column (with rubber tube and a cup) Tune forks (8 frequencies shown below), Mallet, Thermometer

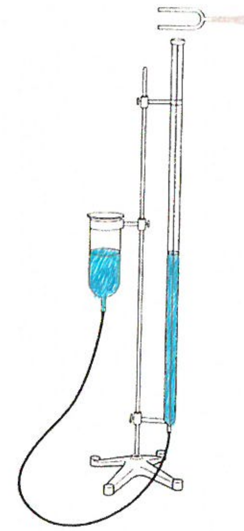
2. Temperature	$t =$ 25.0 °C Speed of Sound $V = 331.5 + 0.6t =$ 346.5 m/s

3. Theoretical Values (Calculate and fill the table below)	Wavelength $\lambda_{theo} = V/f,$ (1) Length of Air Column in resonance $A_{theo} = \lambda_{theo}/4,$ (2) $B_{theo} = 3\lambda_{theo}/4$ (3)

4. Experimental (Observe and fill the table below)	Let the surface level of water move to the area of A_{theo} or B_{theo}, and find the experimental A_{exp} and B_{exp} by the resonance between fork tune and air column. The First Resonance A_{exp} , The Second Resonance B_{exp} (4)(5)

5. Calculation (Calculate and fill the table below)	Wavelength $\lambda_{exp} = 2(B_{exp} - A_{exp})$ (7) Frequency $f_{exp} = V/\lambda_{exp}$ (8) Location of Anti-node at the open end $\Delta A = A_{theo} - A_{exp}$, $\Delta B = B_{theo} - B_{exp}$ (9)

6. The Third Resonance	Theoretical $C_{theo} = \lambda_{theo} + \lambda_{theo}/4 = 5/4\,\lambda_{theo}$ (6) Experimental (C_{exp}) Measurement should be done if C_{theo} is shorter than the tube length



Tune Fork		Theoretical (theo)			Experimental (exp)						
	Frequency f (Hz)	(1) λ_{theo} (cm)	(2) A_{theo} (cm)	(3) B_{theo} (cm)	(4) A_{exp} (cm)	(5) B_{exp} (cm)	(6) C_{theo} / C_{exp} (cm)	(7) λ_{exp} (cm)	(8) f_{exp} (Hz)	(9) ΔA (cm)	(9) ΔB (cm)
C Do	512	67.7	16.9	50.8	15.9	50.0	84.6/85.3	0.682m 68.2	508	1.0	0.8
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D Re	288	120	30.0	90.0	28.8	X	150.0/X			1.2	
C Do	256	135	(33.8) 33.75	(101.3) 101.25	32.3	X	168.8/X			1.5