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Laboratory Report

Title Resonance of a Pipe

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Summary

In this experiment, we observed whether the resonance occurs when the frequency of tuning fork and the natural frequency of air column match. I compared the experimental values and the theoretical values of the wavelength of the sound and the length of air column when resonance occurred.

Throughout the experiment, the resonance occurred and the sound vibrated ...... ?

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

Teacher's Comments

A good report. Read my comment about the calculation of the speed of sound.

1	2	3	4	5	6	7	8	9
Due	Summary	Intro.	Method.	Results	Table/Fig.	Discussion	Clearness	General
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* Use this form as a cover sheet.
* Submit your reports by the seventh day after your lab.

Introduction

Objectives

-To observe the resonance when the frequency of tuning fork and the natural frequency of air column match

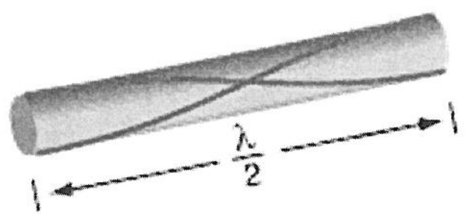
-Calculate the wavelength of the sound from the length of the air column when resonance occurs

Theory

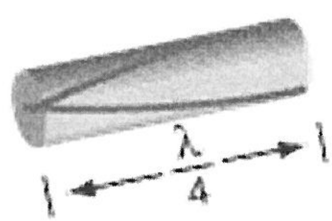
- **Resonance:** is a phenomenon in which an external force or a vibrating system forces another system around it to vibrate with greater amplitude at a specified frequency of operation. The resonance in this experiment occurs when the frequency of tuning fork and the natural frequency of air column match

-**Air Column:** air inside the pipe that is oscillating. The resonance occurs when the frequency of tuning fork and the natural frequency of air column match

-**Open pipe:** tube that has both ends open to the air. Both ends must be anti-nodes.



-**Closed pipe:** tube that has one end closed off, and the other end open. Closed end must be node and opened end must be anit-node

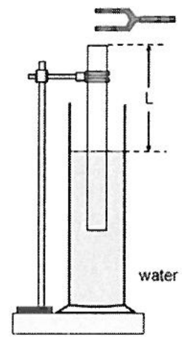


-**End correction**: a short distance applied or added to the actual length of a resonance pipe, in order to calculate the precise resonance frequency of the pipe

Experiment

Materials:

- Air/water column (with rubber tube and a cup)
- Tune forks (8 frequencies)
- Mallet
- Thermometer



Procedures:

1. Measure the temperature by using the formula:
   Speed of sound: $V= 331.5 + 0.6t=$ m/s
2. Use the speed of sound the frequency of 8 tune forks to calculate the theroretical wavelength and the length of air column in resonance
   Wavelength: $\lambda_{theo}= V/f$
   Length of air column in resonance: $A_{theo}= \lambda_{theo}/4$ (First Harmonic)
   $B_{theo}= 3\lambda_{theo}/4$(Second Harmonic)
3. 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
4. Use the value of A_{exp} and B_{exp} to calculate the experimental wavelength, frequency, and location of anti-node at the open end.
   Wavelength: $\lambda_{exp}= 2(B_{exp} - A_{exp})$
   Frequency: $f_{exp}= V/\lambda_{exp}$
   Location of anti-node at the open end: $\triangle A= A_{theo} - A_{exp}$, $\triangle B= B_{theo} - B_{exp}$
5. Calculate the length of air column in resonance of third harmonic
   Theoretical: $C_{theo}= \lambda_{theo} + \lambda_{theo}/4 = 5/4\, \lambda_{theo}$
   Experimental: C_{exp}
   Measurement should be done if C_{theo} is shorter than the tube length

Results

a. Temperature of the air column: t = 25.0℃

b. Speed of Sound: V= 331.5 + 0.6t

= 331.5 + 0.6x25.0

= 346.5 m/s

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) △A (cm)	(10) △B (cm)
C Do	512	67.7	16.9	50.8	15.5	51.2	84.6/	71.4	485	1.4	-0.4
B Ti	480	72.2	18.0	54.1	17.8	54.2	90.2/	72.8	476	0.2	-0.1
A La	426.7	81.2	20.3	60.9	20.5	61	101/	81.0	428	-0.2	-0.1
G Sol	384	90.2	22.5	67.7	24.9	68.6	113/	87.4	396	-2.3	-0.9
F Fa	341.3	102	25.5	76.5			126/				
E Mi	320	108	27.0	81.0			135/				
D Re	288	120	30.0	90.0			150/				
C Do	256	135	33.8	101			169/				

	C	B	A	G	F	E	D	C
Speed of Sound m/s	485 x 0.714 =346.3	476 x 0.728 =346.5	428 x 0.810 =346.7	396 x 0.874 =346.1				

Discussion

- When we hit the tune fork with the mallet and brought close to the rubber tube, a sound like "bwoaann" vibrated at the area of resonance.
  The reason why the sound vibrated is because when resonance is occurred, it is at the state of a system in which an abnormally large vibration is produced in response to an external stimulus, occurring when the frequency of the stimulus is the same as its own natural frequency. Therefore, the sound got big and vibrated.

These calculations does not seem to make any sence because you obtained fexp using V = 346.5 m/s. Right ?

- As we see from the results above, we see that the experimental values are close to the theoretical values. Therefore, we can say that the resonance occurred when the frequency of tuning fork and the natural frequency of air column matched. But there are some difference between the theoretical and experimental value.
  The reason why this change caused is because we were not accurate at reading the scale of the tube and not accurate to hear the resonance in the air column.
- As we can see from (9) and (10), the location of the anti-node was not same at the open end of the pipe.
  The reason why this happened is because it is difficult for us to place the location of anti-node and the open end of the air column both at the same place. This is called end correction. It is a short distance applied or added to the actual length of a resonance pipe, in order to calculate the precise resonance frequency of the pipe.
- By multiplying the f_{exp} and λ_{exp} to define the speed of the sound, all of the speed was very close to the value what we got from **b**.

Conclusion

- When the frequency of tuning fork and the natural frequency of air column match, the resonance occurs and the sound vibrates.
- The location of anti-node is slightly out of the open end of air column. This is called end correction.
- By calculating the wavelength of tuning fork, we are able to calculate the length of air column in resonance.

Opinion

This experiment was very simple and easy for me to understand. Since I have played flute for 3 years, I was very suspicious how my instrument and other instrument vibrated a sound. Throughout this experiment, I understood that the resonance played an important role to it.

Tatsui

References

Shutomo Iwai's Lab Report
Kana Fukuchi's Lab Report