International Baccalaureate

Extended essay cover

Candidates must complete this page and then give this cover and their final version of the extended essay to their supervisor.

Candidate session number	[redacted]
Candidate name	[redacted]
School number	[redacted]
School name	[redacted]

Examination session (May or November)	MAY	Year	2012

Diploma Programme subject in which this extended essay is registered: PHYSICS

(For an extended essay in the area of languages, state the language and whether it is group 1 or group 2.)

Title of the extended essay: Investigating the effects of the Kinetic energy of air particles on the natural power loss of Sound waves

Candidate's declaration

This declaration must be signed by the candidate; otherwise a grade may not be issued.

The extended essay I am submitting is my own work (apart from guidance allowed by the International Baccalaureate).

I have acknowledged each use of the words, graphics or ideas of another person, whether written, oral or visual.

I am aware that the word limit for all extended essays is 4000 words and that examiners are not required to read beyond this limit.

This is the final version of my extended essay. [redacted]

Candidate's signature: [redacted] Date: January 11th 2012

Supervisor's report and declaration

The supervisor must complete this report, sign the declaration and then give the final version of the extended essay, with this cover attached, to the Diploma Programme coordinator.

Name of supervisor (CAPITAL letters) [redacted]

Please comment, as appropriate, on the candidate's performance, the context in which the candidate undertook the research for the extended essay, any difficulties encountered and how these were overcome (see page 13 of the extended essay guide). The concluding interview (viva voce) may provide useful information. These comments can help the examiner award a level for criterion K (holistic judgment). Do not comment on any adverse personal circumstances that may have affected the candidate. If the amount of time spent with the candidate was zero, you must explain this, in particular how it was then possible to authenticate the essay as the candidate's own work. You may attach an additional sheet if there is insufficient space here.

[redacted] worked hard on his project, but did not have enough time to overcome some of the issues such as maintaining a constant temperature. [redacted] required very little help and asked for advice a couple of times. His research seemed appropriate and a run through Turnitin, as requested for all of our students by the IB coordinator, showed that there was no plagiarism. [redacted] has a good understanding of the material as I was quick to question him during the interview process. I predicted a good score for holistic judgment. He has scratched the surface on a difficult topic.

This declaration must be signed by the supervisor; otherwise a grade may not be issued.

I have read the final version of the extended essay that will be submitted to the examiner.

To the best of my knowledge, the extended essay is the authentic work of the candidate.

I spent $\boxed{4}$ hours with the candidate discussing the progress of the extended essay.

Supervisor's signature: [redacted] Date: January 11/2012

Assessment form (for examiner use only)

Candidate session number	[redacted]

Achievement level

Criteria	Examiner 1	maximum	Examiner 2	maximum	Examiner 3
A research question	2	2	2	2	
B introduction	2	2	1	2	
C investigation	2	4	2	4	
D knowledge and understanding	1	4	2	4	
E reasoned argument	3	4	3	4	
F analysis and evaluation	1	4	1	4	
G use of subject language	3	4	3	4	
H conclusion	0	2	0	2	
I formal presentation	4	4	2	4	
J abstract	2	2	1	2	
K holistic judgment	1	4	2	4	
Total out of 36	21		19		

e of examiner 1: [redacted] Examiner number: [redacted]
PITAL letters)

e of examiner 2: [redacted] Examiner number: [redacted]
PITAL letters)

e of examiner 3: ______________________ Examiner number: ______________
PITAL letters)

IB Cardiff use only: **B:** ✓

IB Cardiff use only: **A:** 104833 **Date:** 21/05 temperature of air?

Investigating the effects of the kinetic energy of air particles on the natural power loss of sound waves

molecules ...

✓

a little curiously put..
.. better put afterwards

Put ...

Extended Essay Final Draft

Subject: Physics

Supervisor:

Word count: 3728

Abstract:

RQ

how inv. done

concl.

In the following essay, I will carry out an investigation to find out if there is a relationship between the temperature of air and the magnitude with which sound waves are attenuated as they propagate through the medium. Before doing anything, I state my reasons for choosing this topic and why it interests me. I then start the essay off by giving background information on the topic of sound and its properties and how it works. After introducing the idea of attenuation, I write about Stokes' law and show how it works. I then use the appropriate literature to gather information on the affect of temperature on the mentioned variables. The points are then plotted on a graph to allow me to develop a hypothesis for the effect if temperature on the attenuation of sound. With the hypothesis at hand, I will go on to design an experiment from scratch that will allow me to test my hypothesis. My results will be produced and a graph will be drawn for further analysis. The graph of my results showed that there is a direct correlation between the temperature and attenuation of sound. However, my hypothesis was proven incorrect, the graph produced shows that there is a negative correlation between the two variables, so as the temperature increases, the attenuation decreases. I will then evaluate my work critically and locate possible sources of inaccuracy in my method. I will try to find solutions for the errors I have. The essay will be concluded with a note on how my experiment could be taken further and a peer into what unanswered questions had arisen from the investigation.

v. good.

Word Count: 274 words.

The abstract is in part generic;
The 2nd element incomplete, unclear how/what what done in experimental part

abstract: 1/2

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generic

before Appendix

integrate in the intro.

RQ: 2/2

Research question: Does the temperature of the air affect the attenuation of sound waves that propagate through it? If so, how?

rambling

As a physicist, I notice many things that intrigue me in my everyday life. A simple observation of an ordinary occurrence would get my mind running in an attempt to understand what is really happening and what cause these fascinating phenomena that we see everyday, yet take for granted.

avoid personal pronoun

Being a huge fan of music, I have always had some fascination with sound and how it is heard and perceived by an audience. A thing that I was especially intrigued by was the attenuation of sound and properties that affect it. For most of the properties, I simply know from my past knowledge an intuition, how the attenuation would vary. Then I thought of temperature.

why underline? statement imprecise, inexact

Temperature changes everything. Has this statement any meaning?!

molecules...

basic physics

Temperature by definition is the measure of the average kinetic energy of the particles in a sample of matter[1]. So by increasing the temperature of something, we are increasing the average kinetic energy, and since the mass of the particles in not changing, then the speed of the moving particles must be increasing. Everything is made up of particles, by changing the velocity at which the particles oscillate, we can be sure that many of the substance's properties would change.

in a gas?

rambling

When the time came to write an extended essay, I certainly knew that I would be selecting physics as my subject, but I was not so sure about the specific topic of my essay. But after plenty of thought, I decided to investigate the effects of temperature on the attenuation of sound waves. The reason I selected temperature was because I honestly couldn't think why or how the temperature would affect the overall attenuation. For example, I could imagine that increasing the temperature would decrease the density and increase the viscosity, both of which would have opposite effects on the attenuation.

? how do you know.. speculating

The answer to my research question is not something you can easily look up on Google®, so in order for me to formulate an accurate and correct answer to my research question; lots of research would need to be done.

not for the intro

My hypothesis is that the temperature will indeed have an effect on the attenuation of sound waves, however, my current knowledge does not have the capacity to tell me exactly what would happen, however, my hypothesis is that the attenuation would increase with a temperature increase. This is based on my studies that tell me that an increase in the viscosity would increase the magnitude at which as oscillating object would be damped.

why increase?

generic

Over the remainder of the essay, I will present general background information of the topic and then, based on secondary research, formulate a new and improved hypothesis of the effects. I will then conduct my primary research by designing and executing an experiment to obtain results which will be processed in order for me to confirm or refute my hypothesis.

[1] http://www.thefreedictionary.com/temperature

not listed in biblio

intro: significance, worthiness .. limited .. music .. principles of physics: none in the intro per se, some aspect below but not complete; a lot of padding, rambling in intro and some irrelevant parts

1/2

"background info." see Table of Contents

Firstly, an introduction to sound waves:

Sound waves are mechanical disturbances in mediums such as air. The energy transferred by sound is done via the interaction of particles in the medium with each other. Sound waves propagate longitudinally; this means that the direction of the vibration of the particles and the direction of the energy movement are parallel. The individual particles do not travel all the way from the source to the target; they only move a very short distance. However, by moving this short distance they cause adjacent particles to vibrate as well.

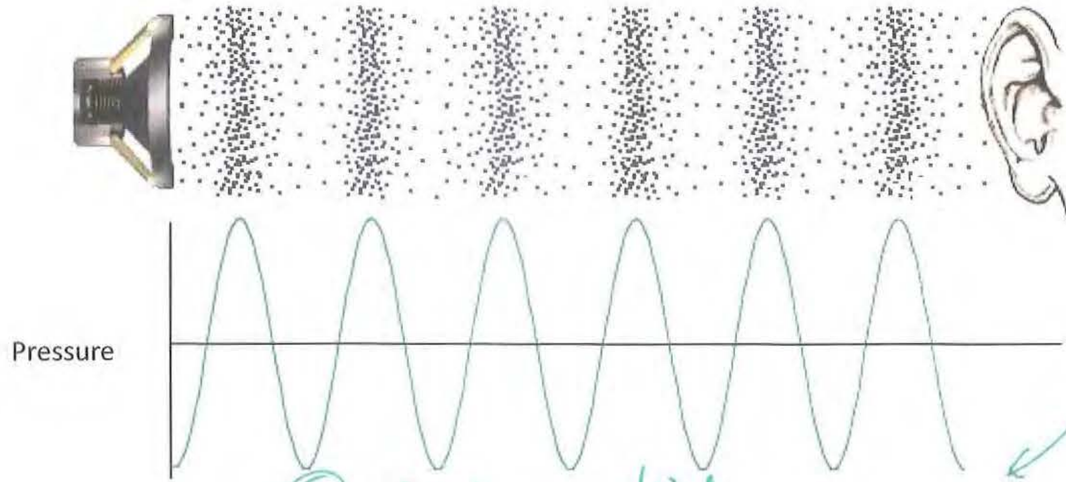


Fig.1. [2]

(I) Fig 1 label

not attenuation per se

These vibrations will result in the formation of regions where the particles will be compressed (high pressure) and regions of rarefaction (low pressure). The energy from this sound wave is propagated through the medium which - in this case - is the air.

(D)

Now obviously this sound wave will not continue to propagate forever, we know this from everyday experience. The further we are from a sound source, the quieter the sound. So we can say that the sound intensity is inversely proportional to the distance to the source ($p \propto \frac{1}{r}$). why not ' $\frac{1}{r^2}$ ' ?? inexact use

- define intensity first
- if source tiny
- geometry ...

X

no need to repeat ?

We know from the law of conservation of energy that the sound energy cannot simply disappear. So what is happening to the sound? answer ?

because spreading ? or $\frac{1}{r}$? on top of it?

Attenuation is the name given to the gradual reduction in the intestiy of the sound wave that occurs as a wave travels though a medium away from the source. There are several factors that affect the attenuation of a wave. The attenuation of sound is dependent on the properties of the medium that it is travelling through and the properties of the sound wave.

underlying / bold letter / usually not needed for a report layout (I)

(D) (F)

which? .. v, λ, f, amplitude ?

absorption, you... → interaction

(D)

More analysis needed here! – what happens to energy? – what is 'intensity'?

[2] http://www.mediacollege.com/audio/images/loudspeaker-waveform.gif

(not listed in biblio)

the bel (using $\log_{10}$) and the neper (using $\log_e$) are not a unit in the SI ; dimensionless
1 Np ~ 9 dB

Explain

Stokes's Law

George Gabriel Stokes came up with a law that can be used to calculate the attenuation of sound. Appropriately named **Stokes's Law for sound attenuation**, the law takes into consideration some vital elements of the medium and the wave. The given unit for attenuation is neper per unit length.

$$\alpha = \frac{2n\omega^2}{3\rho V^3}$$ [3]

(equation 1)

in the text

Where:

α= Attenuation in neper/m

n= Dynamic Viscocity in Pa·s

ω= Sound Frequency in Hz

ρ= Fluid Density in Kg/m^3

V= Speed of sound in ms^{-1}

kg/m^3

m s^{-1}

I used the appropriate literature to find the different values for the properties of air under standard atmospheric conditions but with varying temperatures. I took those results and used them to calculate the attenuation of sound in neper/m in accordance to Stoke's law.

air? kg m^{-3} m s^{-1} Pa s

Temperature (°C)	Dynamic viscosity (Pa.s)[4]	Fluid density (Kg/m3)[5]	Sound speed (m/s)[6]	Attenuation	
				in neper/m	in dB/m
0	1.71E-05	1.293	331.4	0.0000969	0.0008416
5	1.73E-05	1.269	334.4	0.0000972	0.0008444
10	1.76E-05	1.247	337.4	0.0000980	0.0008511
15	1.80E-05	1.225	340.4	0.0000993	0.0008629
20	1.82E-05	1.204	343.3	0.0000996	0.0008654
25	1.85E-05	1.184	346.3	0.0001003	0.0008715
30	1.86E-05	1.165	349.1	0.0001001	0.0008692
40	1.87E-05	1.127	354.7	0.0000992	0.0008612
50	1.95E-05	1.109	360.3	0.0001002	0.0008707
60	1.97E-05	1.060	365.7	0.0001013	0.0008802
70	2.03E-05	1.029	371.2	0.0001029	0.0008934

Since I did not conduct the experiments, I cannot give values for the uncertainties in the results.

Fig.2.

$\omega = 20 \times 10^3$ Hz

no need to both dB in fine

not proper language

Please note: for the frequency, a test frequency of 20kHz was used. Since the same test frequency was used for all values, it does not matter because **the trend, which is what is being studied,** will not be affected.

explain clearly

The results have been plotted on the next page for further ease of analysis:

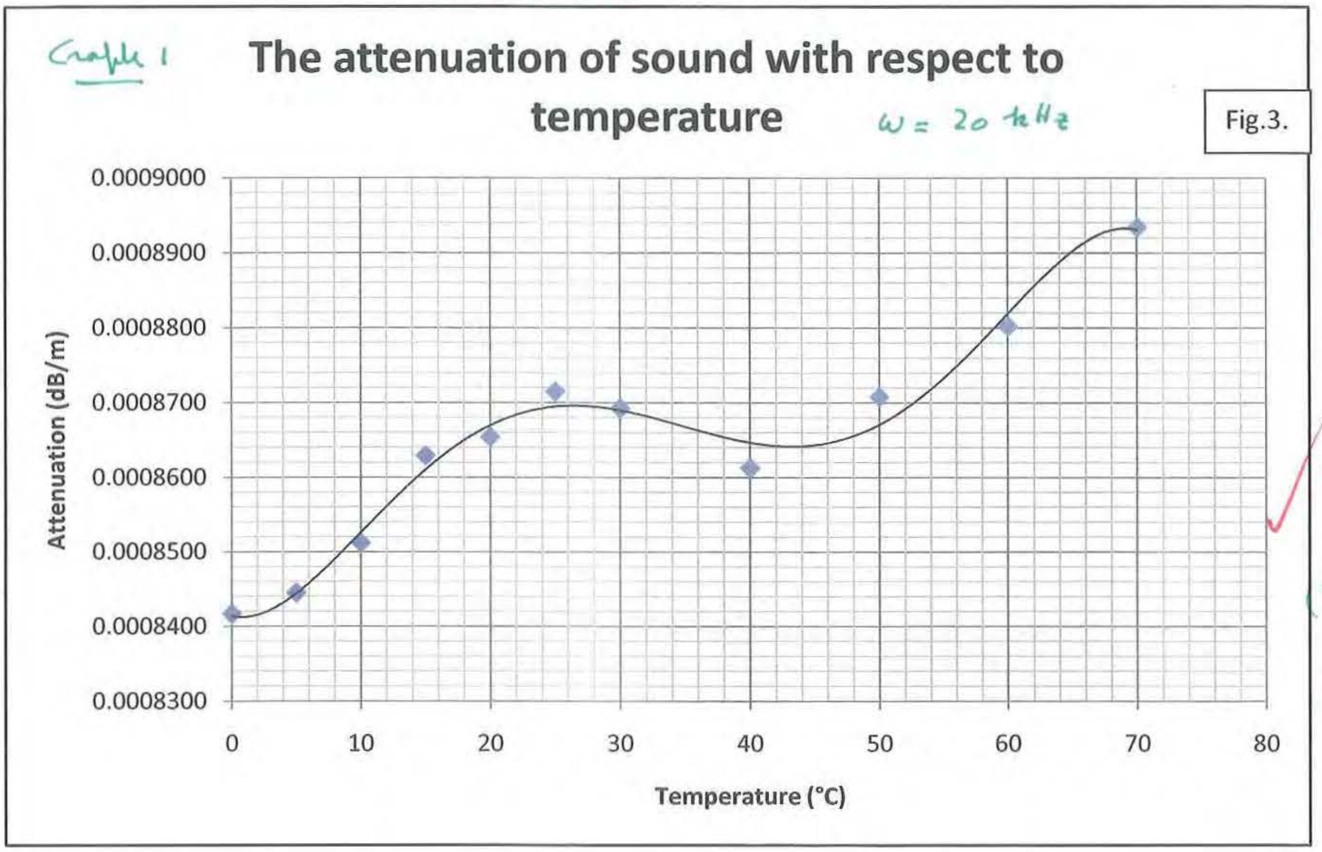
[3] en.wikipedia.org/wiki/Stokes'_law_(sound_attenuation) - **Full source shown in the citations section.**
[4] http://www.essom.com/backend/data-file/engineer/engin12_1.pdf
[5] http://www.engineeringtoolbox.com/air-desity-specific-weight-d_600.html
[6] http://www.engineeringtoolbox.com/air-speed-sound-d_603.html

toolbox

not in bold

not listed in biblio

(F) * there are not data points here .. why not trace a continuous curve ?



data-based

interesting!

(best fit curve?)

data points at 40°C and 50°C ...

From this graph, we can see that the temperature does indeed have an effect on the attenuation of sound. However, the trend is not as simple as I thought it might be. The line of best fit produced can only be represented by a polynomial curve of the 5^{th} degree.

Between the temperatures of 0°C and 25°C the attenuation rises with temperature, then the attenuation begins to decline with increasing temperatures up to 40°C. Then attenuation starts rising again.

(E) should not be form of essay, but ...

This test has somewhat confirmed my hypothesis; the temperature does have an effect on the attenuation of sound, and this trend is a positive trend at most parts. However, this causes some confusion seeing as the trend is so complex. This suggests to me that my hypothesis would only be correct in some regions but incorrect at others. This could be because other properties of air have a greater effect at some temperatures and a less significant one at others.

(F) graph α(n) α(p) α(V) independently and ...

This is worth investigating in its own right. Values from previous data could be individually plotted.

Experimental Planning: Apparatus

The experimental procedure on the following page will clarify things further.

Large Steel pipe:

dimensions

It will give me a controlled environment that I can monitor. This will help me maintain the conditions of the experiment. Obstacles in the environment that could cause effects such as constructive and destructive interference will be maintained. If we conducted the experiment without this, we would need to make sure that entire room is at the same temperature and that things in the room stay in the same place that they are in, so obviously using the steel pipe would make things easier. The length of the pipe is 1m. (± ?)

2 Sound Sensors:

size ? — what is each sensor measure exactly ? in which units ?

diagram

The sound sensors will be measuring the change in the ambient air pressure caused by propagating sound waves. When processed by the computer, this would give us the amplitude of the wave, an important property of the wave that is needed to calculate the attenuation. One sound sensor will be positioned on either side of the pipe. The sound sensors will be connected to the sensor interface. (see diagram p8)

Digital Temperature sensor:

size ?

will the room be entirely at same T & const. T ?

This device will measure the temperature of the room in °C. A digital temperature sensor was chosen over a mercury thermometer because It would give me more precise results and it would allow for the easy import of data into the computer. Also, I can put the temperature sensor inside the pipe and I will be able to take a reading without pulling it out. It also reduced the chance of having a parallax error affect my results.

Air Conditioner:

It will be used to reduce the temperature of the air in the room. This is done so that we can change the controlled variable of the experiment. The air conditioner is used because it will blow out cold air which should cool all the air inside and surrounding the pipe. The air conditioner will be positioned above the pipe and it and the flaps will be pointing downwards.

Portable heater:

It will be used to increase the temperature of the air in the room. This is done so that we can change the controlled variable of the experiment. The portable will heater will blow out heated air which will increase the temperature of the air in and around the pipe. When raising the temperature, the heater will be positioned near one of the entrances of the pipe, then it will be positioned in the other end. The heater will be removed before any readings are taken.

Small Speaker:

characteristics - source of sound ? - range of frequencies

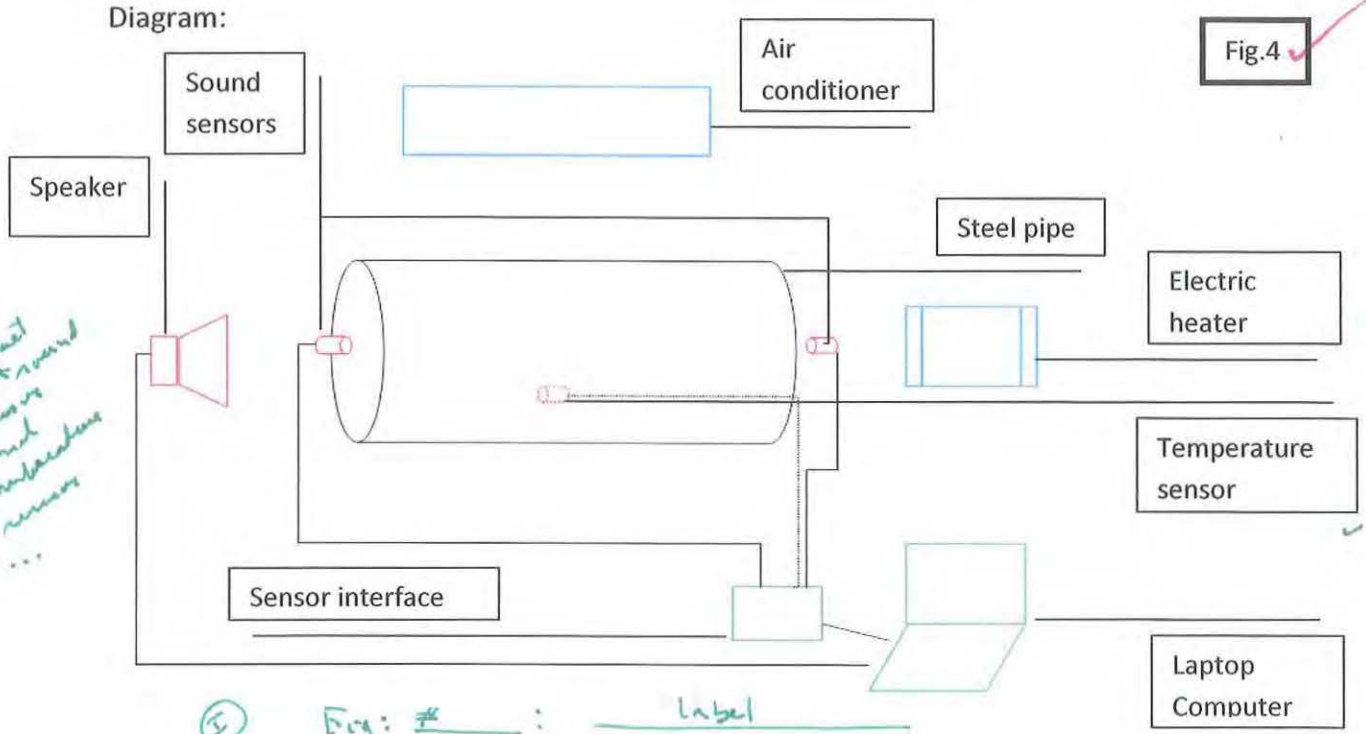
This will be plugged into the laptop and will be used to create the sound. This is used because It will allow a specific position for the sound source to be pinpointed.

Computer and sensor interface with the DataStudio© software:

A key piece of apparatus, the sensor interface will be used to convert all the analogue signals coming from all the sensors to a digital signal so that it could be read and interpreted by the computer. The sensor interface will then be connected to the computer. The computer, with the use of the DataStudio© software, will then use all the gathered information to draw a graph of Amplitude against time for every temperature.

Experimental Planning: Method

Diagram:



(I) Fig: # : label

Method:

1. The apparatus will be setup as shown in the diagram above.
2. The DataStudio© software will be turned on and the appropriate procedure will be followed in setting up the sensors so that a graph on the computer displays the Voltage against the time.
3. The temperature will be recorded.
4. The audio track will be played 4 times. frequency (ies) ?
5. 4 peak amplitudes will be generated on the graph because of this.
6. The 4 peak amplitudes of both graphs will be taken at the appropriate points and recorded on my table of results.
7. One of either the air conditioner or the electric heater will be used to change the temperature of the air accordingly. — how do you know it is done uniformly?
8. When the temperature of the air is changed enough, the new temperature will be recorded and the a new worksheet will be setup on the software.
9. The audio track will be played another 4 times and the appropriate readings will be taken.
10. The experiment will be repeated at 4 different temperatures.
11. The recorded values will then be processed accordingly in order to display the attenuation of air at different temperatures which will then be plotted on a graph for analysis.

cookbook recipe style: not for an EE (research paper)

(I) elaborate

not as clear, complete

Experimental Planning: Variables

The independent variable for this experiment is the temperature of the room.

The dependent variable is the power loss of the sound wave.

The controlled variables include:

Controlled Variables	
Variable	**How it will be controlled**
Properties of the pipe (thinkness, length, colour...)	The same pipe will be used in all experiments.
The properties of the sound entering the pipe.	The same audio file will be used and it will be played from the same laptop at the same volume and connected to the same speaker located at a fixed position away from the pipe.
Background noise levels	The tests will be conducted in the same room at the same time when minimum noise levels can be achieved.

how sound will propagate down the tube?

(... without air conditioner on ...)

why use " ... " ?

?

Data Collection & Processing: Calculating the Attenuation

If we look at the units used, we would see that the attenuation is defined as the power loss per unit length. what are they?

Part

$$Attenuation = \frac{Power\ Loss}{Length}$$

(equ^n #)

Where:
a = Attenuation (dB/m)
P_i= Power entering the pipe(W)
P_o= Power exiting the pipe(W)
V= Voltage recorded (V)
L = Length (m)

a, V and L not in equ^n

$$Power\ loss\ (\ in\ dB) = 10\log_{10}\left(\frac{P_{in}}{P_{out}}\right)$$

$\left(\frac{P_o}{P_i}..\right)$

Since we know that,

$$P = IV$$

?

what is measured? by sensor? ∴ is?

This is nonsense!!

We can say that the power is proportional to the voltage. Since they are proportional, the ratio of the voltages would equal the ratio of the power values.

So I will use the graph to obtain the values for the voltage entering and exiting the pipe. of?

I?

So putting these formulae together, we would get:

not good layout (I)

Fig.6. ?

$$a = \frac{10\log_{10}\left(\frac{V_{in}}{V_{out}}\right)}{L}$$

(equ^n #)

per unit of length (G)

This formula would allow for the calculations of the attenuation of sound at any temperature with the use of the amplitude (voltage).

Temp? same conditions?

T= ? ω = ?

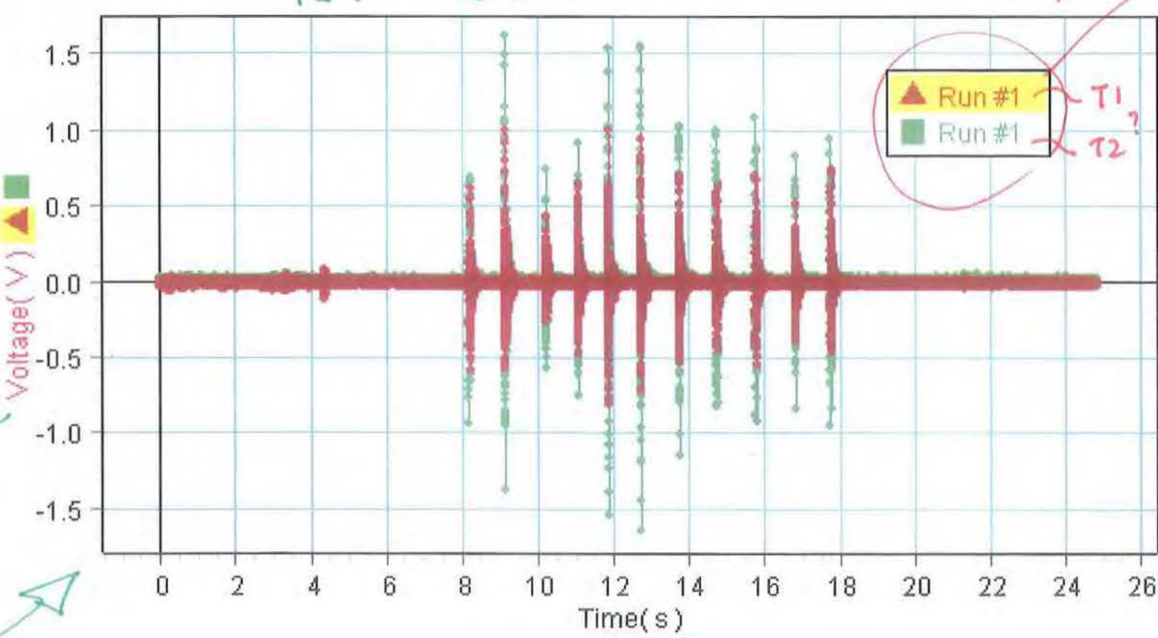


Fig.5.

not def.

Comments needed .... Fig # : label

Explain the Data table .. each column is

Data Collection & Processing: Raw and processed Data

±?

Raw Data ±?				Temperature °C	Attenuation (dB/m)
Temperature 1				12.3	
		Mic 1	Mic 2		
Amplitudes	T1	2.23	1.62		1.39 ±?
	T2	2.22	1.68		1.21
	T3	2.22	1.67		1.24
	T4	2.24	1.64		1.35
				Average:	1.30 ±?

units?

values..?

{± on an average value?}

Temperature 2				21.4	
		Mic 1	Mic 2		
Amplitudes	T1	2.23	1.69		1.20
	T2	2.22	1.68		1.21
	T3	2.23	1.64		1.33
	T4	2.23	1.66		1.28
				Average:	1.26

Temperature 3				33.9	
		Mic 1	Mic 2		
Amplitudes	T1	2.24	1.70		1.20
	T2	2.22	1.62		1.37
	T3	2.22	1.66		1.26
	T4	2.24	1.67		1.28
				Average:	1.28

Temperature 4				39.8	
		Mic 1	Mic 2		
Amplitudes	T1	2.23	1.69		1.20
	T2	2.23	1.69		1.20
	T3	2.24	1.72		1.15
	T4	2.22	1.68		1.21
				Average:	1.19

Temperature 4				56.2	
		Mic 1	Mic 2		
Amplitudes	T1	2.23	1.69		1.20
	T2	2.23	1.73		1.10
	T3	2.23	1.72		1.13
	T4	2.24	1.69		1.22
				Average:	1.16

must be included in data tables

Data Collection & Processing: Calculating the Uncertainty

The uncertainty of the voltage will equal the smallest unit that could be recorded which in this case is ±0.01 ?

GT

I will divide this by the V_1 to get the percentage uncertainty of the voltage

The same process will be repeated for the V_2. Then the percentage uncertainties will be added.

± of attenuation ?

Then this percentage uncertainty will be added to the percentage uncertainty of the length which would be $\frac{\pm 0.001\text{m}}{1\text{m}} = \pm 0.001\%$

log. function ± on ± α/L ?

Finally, the total percentage uncertainty would be multiplied by the attenuation at the point accordingly to give the absolute uncertainty at the point.

Since no calculations were made using the temperature, the uncertainty for the temperature will remain at ±0.1°C at all times.

The uncertainties are given below:

average value

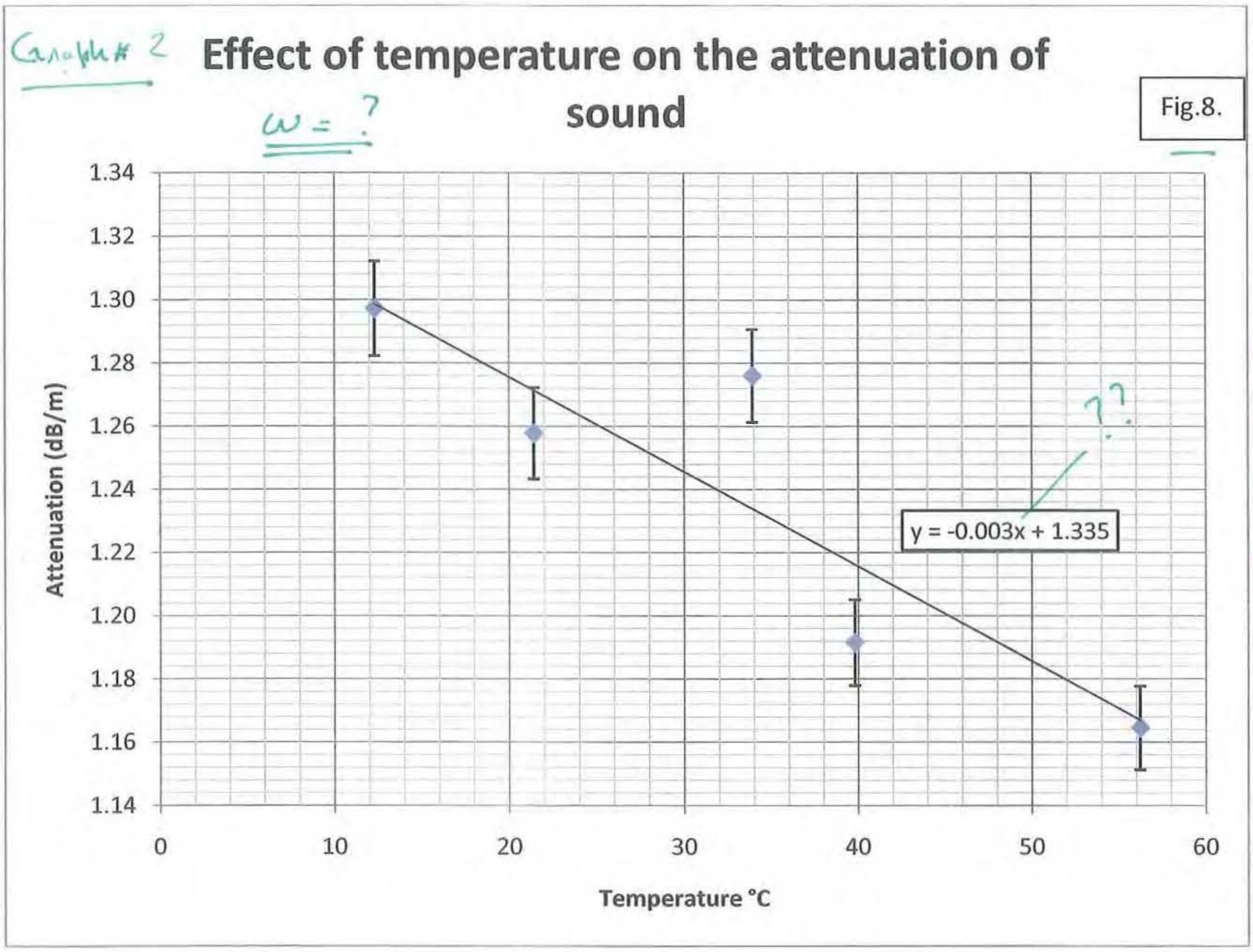
Temperature (°C)	Attenuation (dB/m)	Absolute Attenuation Uncertainty
12.3	1.30	0.015
21.4	1.26	0.014
33.9	1.28	0.015
39.8	1.19	0.014
56.2	1.16	0.013

not ± on average value

Detailed values for obtaining all of these values are shown in the appendix.

Data Collection & Processing: Graph and Analysis

what was ω? 20 kHz as in theoretical part? was ω constant & a same value of temperatures?



not a best fit ... outliers

This graph illustrates the effect of the temperature on the attenuation of sound waves. From this graph we can see that there is a trend present. A drop in the attenuation is visible throughout the graph, however, the changes are not very significant and are barely noticeable. This is somewhat consistent with the trend in the attenuation we have noticed in the previous graph generated, where there was a drop in the attenuation between the temperatures of 20°C and 40°C. However, the graph generated before showed an increase in the attenuation when the temperature rises above 40°C and as it drops below 10°C. These changes in the attenuation were not present when we attempted to reproduce the results experimentally.

? which ? "Graph 1" page 6

not too sure!

it's almost a mirror image!!

Most of the results fall within or in close proximity to the error bars. However, the third reading suggests that there might be a rise in the attenuation. Seeing as this result does not match the trend we can see, I decided to treat it as an anomaly and exclude it from my results. The fourth reading also falls a little outside the allowed range, but the result follows the same trend.

could be

?

Experimental Evaluation

Since the trend produced by the graph is a negative one, we can say that the hypothesis that I came up with at the start of the essay has been proven wrong by the results obtained by the experiment.

As with any investigation, there were many possible sources of error in this experiment. The potential causes of error are discussed below and ways of minimizing these effects will be demonstrated.

1. The velocity of the air in pipe was not taken into consideration. When I used the electric heater, hot air was **blown** into the pipe. The direction and magnitude of the air's velocity would have an effect on the speed of sound which, as we know, would have a significant affect on the attenuation. The temperature differences in the room could have also caused a convection current to flow in the room. A real problem!
2. The equipment used were basic and imprecise, my results could be improved if I used more sensitive sound sensors that would allow me to get more accurate values for the amplitudes. The accuracy of my results could have been improved further if the frequency of the readings was increased. The reason I did not do this is because the computer I was using was not able to handle such fast processes. Another way I could've made my experiment better would be to use a longer pipe. This would have a greater value for the power loss which would increase the difference between the obtained values for the attenuation. why? not worth mentioning
3. Conducting this experiment over prolonged durations would cause a flux in the humidity, this would have an effect on the attenuation. I could use the humidity sensors I have at my disposal to monitor the changes on the humidity and make an attempt at maintaining the levels.

Essay Conclusion

theory

My investigation was split into two parts, both approaches were designed to find the same thing, but they took different approaches in doing so. The first approach was entirely theoretical and employed only research from secondary sources. I then processed these results accordingly in order to obtain what I really wanted.

exp.

I then took a second approach which was an experimental one. I designed an experiment that allowed me to obtain first hand (primary) data which I used to support my hypothesis which was developed in the first step. I think the fact that I used multiple approaches to answer the same question is what made my argument most effective.

I believe that the answer that I have presented for the research question is definitely sufficient for an extended essay. However, I cannot say it is nearly sufficient to satisfy my curiosity on this subject that I have been studying. I plan on pursuing this investigation further in the future if I have the ability to and if my schedule will allow it.

no theory not verified

My investigation was completed successfully and allowed me to discover if a trend between the temperature of air and the attenuation of sound waves propagating through it. I was also able to begin seeing a trend in the plotted graph. However, after completing this experiment, I realise that I have more questions now than I did before. I still do not understand why the temperature of the air affects the attenuation of sound in such a way. Much more extensive research is required to answer that.

⇒ back to the theory ..; but again paradoxical

not relevant to RQ per se

Furthermore, I have been forced to wonder if such a trend is only present when the medium used is air. Perhaps it is a fundamental property of the air that causes such an effect, this led me into thinking about the types of results I might encounter if the medium I used is a liquid seeing as properties such as the viscosity decrease with a rise in temperature, contrary to what would happen if air was the medium.

One last room for further investigation would be carrying out an investigation into the motion of transverse waves through the medium. Since sound waves are longitudinal waves, the way they move through a medium would differ entirely.

investigation: not clear what the signal was, was it constant frequency? even power measured exactly? little evidence of sources consulted; procedure problematic;

knowledge*: overview of relevant sound properties incomplete; lack of definition / explanation; relevant key equations brought up ⇒ some awareness of academic context;

presentation: documentation not well presented; organisation generally helpful; style + layout not good;

holistic: initiative taken, creativity shown, limited amount of data in an experiment difficult to do; out of the beaten path investigation;

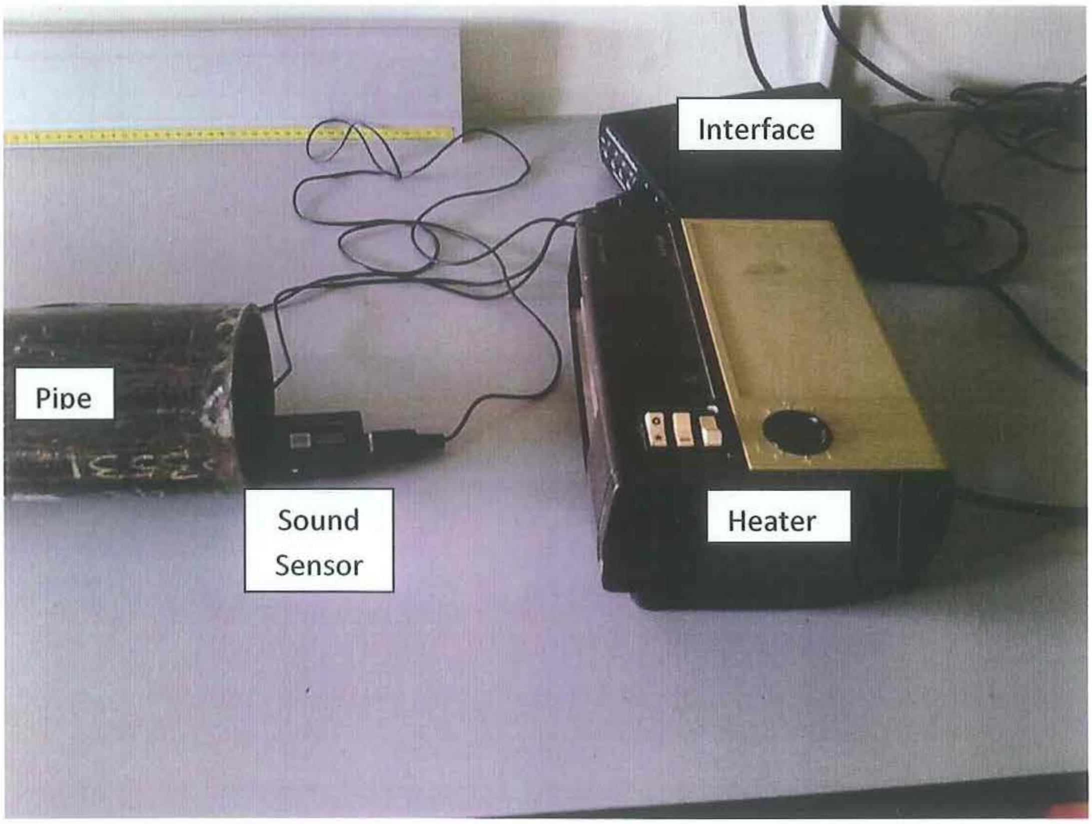
What is your conclusion!!

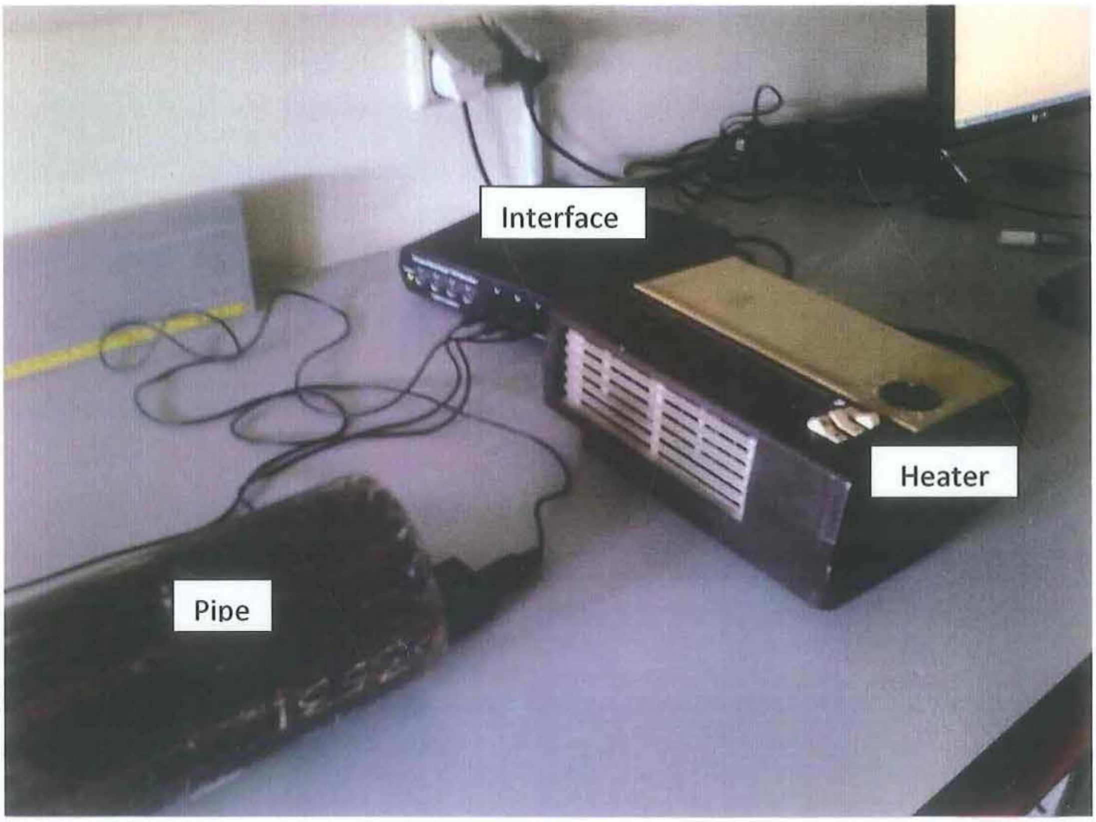
* the focus on "hypotheses" distracted from more in depth work at physics;

not part of EE per se

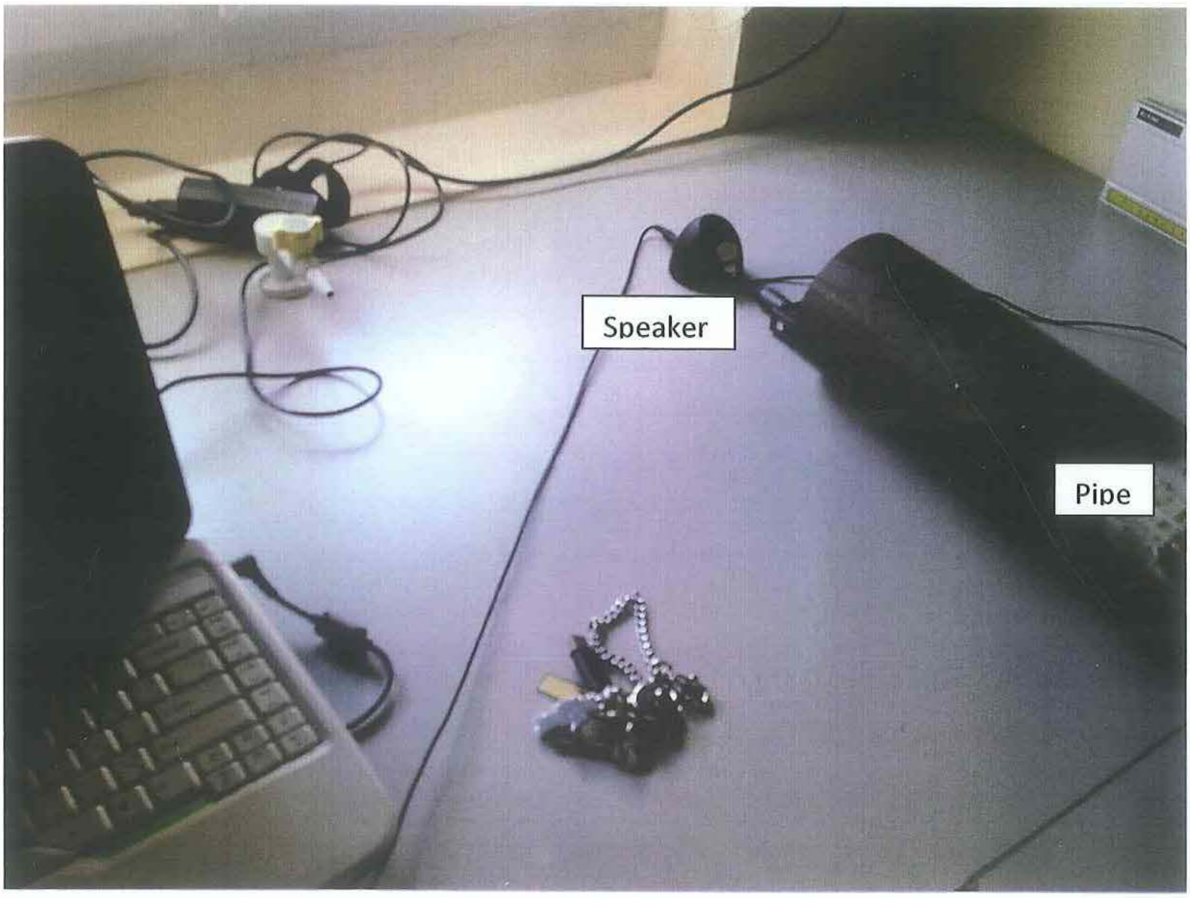
Appendix I:

Photographs of the experiment and equipment:





alignment of speaker ?



Air Conditioner

!!

?

Appendix II:

?

Calculating the Uncertainties					
U in L	U in V	V1 %% U	V2 %U	Total %U	Absolute Attenuation Uncertainty (±dB/m)
0.01	0.01				
		0.004	0.006	0.012	0.016
		0.005	0.006	0.011	0.014
		0.005	0.006	0.011	0.014
		0.004	0.006	0.012	0.016
				Average:	0.015
		0.004	0.006	0.011	0.014
		0.005	0.006	0.011	0.014
		0.004	0.006	0.012	0.015
		0.004	0.006	0.012	0.015
				Average:	0.015
		0.004	0.006	0.011	0.014
		0.005	0.006	0.012	0.016
		0.005	0.006	0.012	0.015
		0.004	0.006	0.011	0.015
				Average:	0.015
		0.004	0.006	0.011	0.014
		0.004	0.006	0.011	0.014
		0.004	0.006	0.011	0.013
		0.005	0.006	0.011	0.014
				Average:	0.014
		0.004	0.006	0.011	0.014
		0.004	0.006	0.011	0.012
		0.004	0.006	0.011	0.013
		0.004	0.006	0.011	0.012
				Average:	0.013

One example in core of essay

Detailed method for obtaining the first row of uncertainties:

V_1%U: $\frac{0.01}{2.23} = 0.004 \ldots$

V_2%U: $\frac{0.01}{2.23} = 0.006 \ldots$

Total%U: $0.004 \ldots + 0.006 \ldots + 0.001 = 0.012 \ldots$

Absolute Attenuation Uncertainty: $0.012 \ldots * 1.36 \ldots = \pm 0.016\ dB/m$

± as log function?

± log function per unit of length

$l \pm \delta l$?

Appendix III:

Explanation of illustrations, tables and graphs:

Item	Explanation
Fig.1.	Image illustrating the propagation of sound waves and the relation of pressure to amplitude.
Fig.2.	Table of results for the change in variables affecting the attenuation of sound at different temperatures.
Fig.3.	Graph displaying the results of the attenuation at different temperatures using the values in Fig.2.
Fig.4.	Diagram demonstrating the plan and setup of the experiment that will be carried out
Fig.5.	Image illustrating the layout of the graph produced by the DataStudio© software. Please note that these are not real results obtained and used, they are simply used as an example.
Fig.6.	Table illustrating all the raw data obtained and the processed attenuation that emerged from it.
Fig.7.	Table showing the uncertainties calculated in for each of the values for the attenuation.
Fig.8.	The graph of results produced from experimentation.

actually only 1 source cited in core of essay

biblio. comes before appendix

Works Cited

not cited in core of essay

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Stokes, G. G. (1819). *Transactions of the Cambridge Philosophical Society: Volume the Eighth.* London: Cambridge University Press.

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not cited

some sources cited in core of essay not listed here in biblio

Criterion	Comment	
A RQ	Fine	2
B Intro	Good research to create hypothesis. Context is clear.	2
C Invest	Good manageable xptal set-up. More data needed for a reliable graph.	2
D Kn & Un	Some relevant aspects of intro. missing. Not so ~~cop~~ comfortable with conceptual physics at deeper level. Confusion of P = IV !! (p10)	~~2~~ 1
E Argu	Presented logically & coherently, with a few aspects missed.	3
F An & Ev	± ✓ Weak "evaluation" (p14) More tussling with anomalies needed.	1
G Lang	"inversely prop" .... ✗ Good diagrams ✓	3
H Conc	None given.	0
I Pres	Cont. – just OK! Bib. ✓ Good.	4
J Abst	Clear & focused!	2
K Hol	Independence of height. Good to have both th. & xptal results. Creativity in design ✓ but not overly insightful. Lacking in analytical depth.	1