St. Mary's Anglican Girls' School

Sound Waves Test

2007

CONSTANTS

PLEASE REFER TO CONSTANTS SHEET FOR FORMULAS AND CONSTANTS

NAME_____

SCORE _____/ 52

SHOW ALL WORKING OUT FOR NUMERICAL ANSWERS

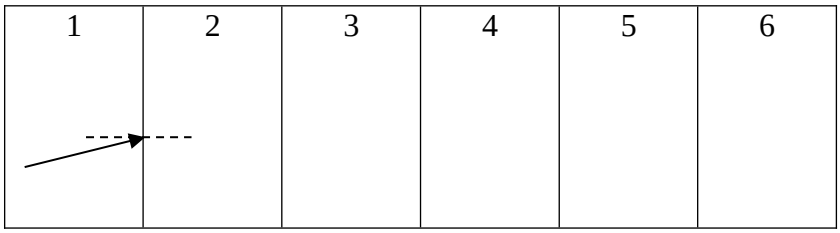
1a) Organise the following substances starting with the substance in which a sound will travel slowest and finishing with the substance in which a sound will travel fastest.

	Substance	**Temperature (^{0}C)**
A	Air	100
B	Steel	10
C	Water	90
D	Steel	50
E	Water	20
F	Air	20

Slowest	1	2	3	4	5	6	**Fastest**
Substance							Substance

(2 marks)

b) The substances in part a) above are now are placed in contact with each other in the order you have chosen as shown in the diagram below.



Note :- there is NO NEED to complete the diagram.

A sound wave strikes the boundary between the first and second medium at an angle of 10^0 to the normal. As the wave progresses through the other mediums, what will happen to the direction of the sound wave? Why?
Note :- no calculations are required

(2 marks)

c) What will happen to the following properties of the sound as it progresses from medium to medium? Use words such as **increase, decrease or no change**.

Speed	**Wavelength**	**Frequency**	**Amplitude**

(2 marks)

2a) A student is trying to calculate the speed of sound in air on a particular day using echoes. The student has had his ears tested. He knows that he can just distinguish between two sounds separated by a time interval of 0.125 s. The student places himself 1.00×10^2 m from a large flat wall. The student has a starter pistol, stopwatch and good reflexes. The stop watch reads 0.597s. What is the speed of sound on that particular day?

(2 marks)

b) How close can the student get to the wall and still just distinguish between the original sound and the echo bouncing off the wall?

(2 marks)

c) If there is a breeze blowing from behind the student towards the wall will this effect the measurement of the speed of sound? Explain

(3 marks)

3. Two loud speakers in a stereo system at a theatre are separated by 10.0 m. In order to test them, Shannon connects them to a single frequency generator so that they produce coherent waves. At first Shannon stands 24 m directly in front of the right hand speaker.

a) What is the path difference ($|l_1 - l_2|$) from the speakers to Shannon?

(2 marks)

b) What is the longest wavelength of sound from the speakers which will result in her hearing a minimum of intensity?

(2 marks)

c) What is the lowest frequency of sound that will result in her hearing a maximum of intensity?

(2 mark)

d) Shannon has set the frequency generator to produce 850 Hz signals. What does she hear?

(3 marks)

e) Shannon now moves to the left, so that she is 24m directly in front of the other speaker. How many times did she hear the sound increase in intensity as she moved across? Explain.

(2 marks)

4 A music teacher is trying to explain to some music students why they are "out of tune" with each other. Luckily both of the students also take Year 12 physics.

a) Name the physics term that describes what will occur if the first instrument (an oboe) plays a frequency of 440 Hz and the second instrument (a trumpet) plays a frequency **slightly** higher **or** lower that that of the oboe?

(1 mark)

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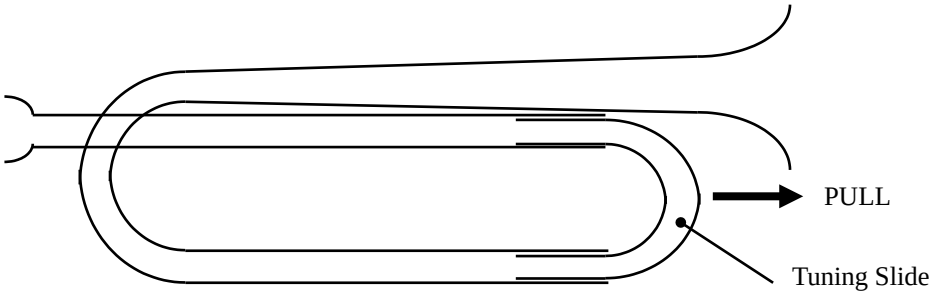
b) The music teacher detects 7 fluctuations in the loudness of the combined oboe / trumpet sound each second. What is the frequency being generated by the trumpet?

(3 marks)

c) The trumpet player attempts to match the frequency of the oboe by **slightly** "pulling out" their tuning slide and so increasing the overall length of the trumpets tubing as shown in the cross sectional diagram of the trumpet below.



When the trumpet player does this, the number of fluctuations in the loudness of the new combined trumpet / oboe sound, decreases. What was the original frequency of the trumpets sound?

(1 mark)

d) If the tuning process continues, how will the trumpet player know that they are "in tune" with the oboe? Explain

(2 marks)

e) Why does an oboe sound different from the trumpet even though they are playing the same note (in tune)?

(2 marks)

5. An open pipe of length 3.70×10^{-1} m is playing its 5th overtone. The frequency of the sound produced by the pipe is 2.82×10^{3} Hz.

a) Sketch the waveform of this frequency in the pipe.

(1 mark)

b) Assuming there are no end effects associated with the ends of the pipe, **calculate** the speed of sound in the air in the pipe on that day.

(3 marks)

c) Calculate the frequency of the lowest note that this pipe can produce on that day.

(2 marks)

d) What is the highest possible approximate frequency that the average human is able to hear?

(1 mark)

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e) Calculate the largest **harmonic** number that a human will be able to hear from this pipe?

(3 marks)

f) If the pipe was sealed at one end to make it a closed pipe, will it still be able to produce a frequency of 2.82×10^3 Hz? Explain with the assistance of a calculation.

(4 marks)

6. A coloratura soprano (a singer which is capable of singing very high and loud) has been employed to sing the role (character) of a screaming nagging parent of a physics student who has not done his homework in a modern opera called "St Mary's". In one of the scenes, the soprano (parent) is required to sing so loud that a crystal wineglass sitting on a shelf explodes.

a) What is the best frequency for the singer to sing at in order to break the wine glass with minimum effort? Why?

(2 marks)

b) For the glass to break it must absorb 1.00×10^{-3} J of energy each second over its surface area of 75.0 cm^2. The loudest sound that the opera singer can produce at any frequency is 125 dB when measured at a distance of 1.00 m from her. An exploding wine glass can throw shards of glass up to 3 m. Calculate the maximum distance from the glass that the opera singer can stand to vocally break the glass and so decide if she needs safety glasses?

(3 marks)

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2007

Answers

CONSTANTS

PLEASE REFER TO CONSTANTS SHEET FOR FORMULAS AND CONSTANTS

NAME_____ANSWERS_____

SCORE _____/ 52

SHOW ALL WORKING OUT FOR NUMERICAL ANSWERS

1a) Organise the following substances starting with the substance in which a sound will travel slowest and finishing with the substance in which a sound will travel fastest.

	Substance	**Temperature (^{0}C)**
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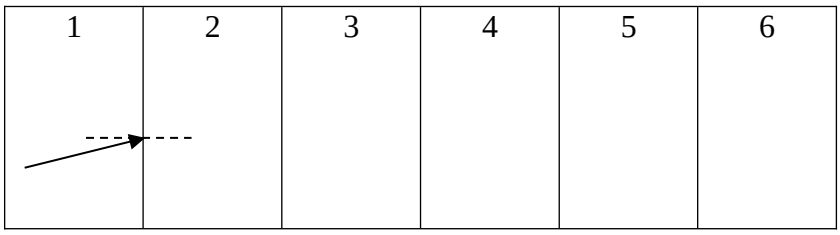
B	Steel	10
C	Water	90
D	Steel	50
E	Water	20
F	Air	20

Slowest	1	2	3	4	5	6	**Fastest**
Substance	*F*	*A*	*E*	*C*	*B*	*D*	Substance

(2 marks)

b) The substances in part a) above are now are placed in contact with each other in the order you have chosen as shown in the diagram below.



Note :- there is NO NEED to complete the diagram.

A sound wave strikes the boundary between the first and second medium at an angle of 10^0 to the normal. As the wave progresses through the other mediums, what will happen to the direction of the sound wave? Why?
Note :- no calculations are required

(2 marks)

Sound wave will gradually bend towards the top of the page.

Δ medium → Δ Speed → Δ Direction

c) What will happen to the following properties of the sound as it progresses from medium to medium? Use words such as **increase, decrease or no change**.

Speed	**Wavelength**	**Frequency**	**Amplitude**
Increase	Increase	No change	No change Or Decrease

(2 marks)

2a) A student is trying to calculate the speed of sound in air on a particular day using echoes. The student has had his ears tested. He knows that he can just distinguish between two sounds separated by a time interval of 0.125 s. The student places himself 1.00×10^2 m from a large flat wall. The student has a starter pistol, stopwatch and good reflexes. The stop watch reads 0.597s. What is the speed of sound on that particular day?

(2 marks)

v = ?
s = 2 x 100 m = 200 m *not mixing incorrect times and distances* *(1)*
t = 0.597 s

v = s/t
v = 200 / 0.597
v = 335 m/s ***(1)***

b) How close can the student get to the wall and still just distinguish between the original sound and the echo bouncing off the wall?

(2 marks)

s = ?
v = 335 m/s
t = 0.5 x 0.125 = 0.0625 s *not mixing incorrect times and distances* *(1)*

v = s/t
335 = s / 0.0625
335 x 0.0625 = s

s = 20.9 m from wall ***(1)***

c) If there is a breeze blowing from behind the student towards the wall will this effect the measurement of the speed of sound? Explain

(3 marks)

no *(1)*

The additional speed that the sound gains on the way to the wall will be lost on the return journey *(1)*

3. Two loud speakers in a stereo system at a theatre are separated by 10.0 m. In order to test them, Shannon connects them to a single frequency generator so that they produce coherent waves. At first Shannon stands 24 m directly in front of the right hand speaker.

a) What is the <u>path difference</u> ($|l_1 - l_2|$) from the speakers to Shannon?

(2 marks)

Pythagoras hypotenuse = square root of ($24^2 + 10^2$)
Hypotenuse = 26 m ***(1)***

26 – 24 = path difference
Path difference = 2 m ***(1)***

b) What is the longest wavelength of sound from the speakers which will result in her hearing a minimum of intensity?

(2 marks)

$n^o = (|l_1 - l_2|) / \lambda$
$½ = 2 / \lambda$ *(1)*
$\boldsymbol{\lambda = 4\ m}$ ***(1)***

c) What is the lowest frequency of sound that will result in her hearing a maximum of intensity?

(2 mark)

$n^o = (|l_1 - l_2|) / \lambda$
$1 = 2 / \lambda$
$\boldsymbol{\lambda = 2\ m}$ ***(1)***

$f = v / \lambda$
$f = 346 / 2$
$\boldsymbol{f = 173\ Hz}$ ***(1)***

d) Shannon has set the frequency generator to produce 850 Hz signals. What does she hear?

(3 marks)

$\lambda = v / f$
$\lambda = 346 / 850$
$\boldsymbol{\lambda = 0.407\ m}$ *(1)*

$n^o = 2 / 0.407\ m$
$\boldsymbol{n^o = 4.91}$ *(1)*
n^o = close to whole number therefore constructive interference therefore louder. ***(1)***

f) Shannon now moves to the left, so that she is 24m directly in front of the other speaker. How many times did she hear the sound increase in intensity as she moved across? Explain.

(2 marks)

5 4 3 2 1 0 1 2 3 4 5 ***(1)***
10 times ***(1)***

Start Finish

4 A music teacher is trying to explain to some music students why they are "out of tune" with each other. Luckily both of the students also take Year 12 physics.

a) Name the physics term that describes what will occur if the first instrument (an oboe) plays a frequency of 440 Hz and the second instrument (a trumpet) plays a frequency **slightly** higher **or** lower that that of the oboe?

(1 mark)

Beats **(1)**

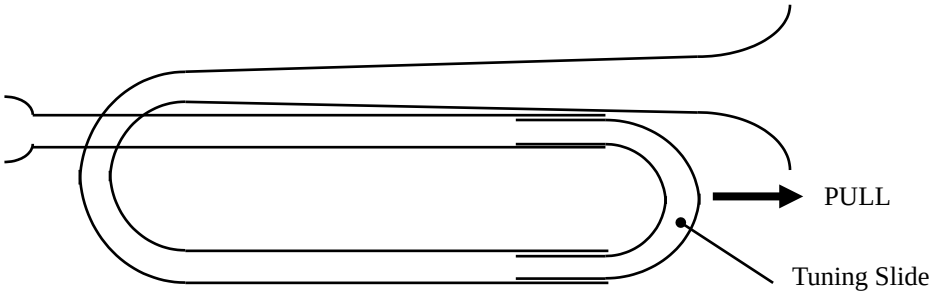
b) The music teacher detects 7 fluctuations in the loudness of the combined oboe / trumpet sound each second. What is the frequency being generated by the trumpet?

(3 marks)

$f_{beats} = |f_1 - f_2|$ ***(1)***

f = 440 + 7 = 447 Hz ***(1)***
or
f = 440 – 7 = 433 Hz ***(1)***

c) The trumpet player attempts to match the frequency of the oboe by **slightly** "pulling out" their tuning slide and so increasing the overall length of the trumpets tubing as shown in the cross sectional diagram of the trumpet below.



When the trumpet player does this, the number of fluctuations in the loudness of the new combined trumpet / oboe sound, decreases. What was the original frequency of the trumpets sound?

(1 mark)

447 Hz ***(1)***

d) If the tuning process continues, how will the trumpet player know that they are "in tune" with the oboe? Explain

(2 marks)

The number of beats will continues to decrease as they continues to pull out their tuning slide and make the length of the pipe longer **(1)**

Eventually there will be no beats. This means they are both producing the same frequency and so are in tune with each other. **(1)**

e) Why does an oboe sound different from the trumpet even though they are playing the same note (in tune)?

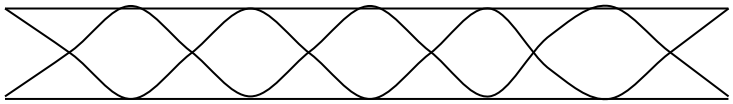
(2 marks)

The oboe contains a different mixture of harmonics **(1)** *compared to the trumpet, which changes the overall timbre (flavour) of the sound* **(1)**.

5. An open pipe of length 3.70×10^{-1} m is playing its 5th overtone. The frequency of the sound produced by the pipe is 2.82×10^{3} Hz.

a) Sketch the waveform of this frequency in the pipe.

(1 mark)



b) Assuming there are no end effects associated with the ends of the pipe, **calculate** the speed of sound in the air in the pipe on that day.

(3 marks)

f = n v / 2 l ***(1)***

2820 = 6 v / 2 x 0.37 ***(1)***

v = 347 m/s ***(1)***

c) Calculate the frequency of the lowest note that this pipe can produce on that day.

(2 marks)

f = n v / 2 l

f = 1 347 / 2 0.37l ***(1)***

f = 469 Hz ***(1)***

d) What is the highest possible approximate frequency that the average human is able to hear?

(1 mark)

20 000 Hz ***(1)***

e) Calculate the largest **harmonic** number that a human will be able to hear from this pipe?

(3 marks)

f = n v / 2 l ***(1)***

20 000 = n x 347 / 2 x 0.37 ***(1)***

n = 42 ***(1)***

f) If the pipe was sealed at one end to make it a closed pipe, will it still be able to produce a frequency of 2.82×10^3 Hz? Explain with the assistance of a calculation.

(4 marks)

no ***(1)***

closed pipes can not produce even numbered harmonics ***(1)***

f = n v / 4 l ***(1)***

2820 = n 347/ 4 0.37

n = 12 ***(1)***

12 is an ever number and so the pipe can not produced this frequency.

6. A coloratura soprano (a singer which is capable of singing very high and loud) has been employed to sing the role (character) of a screaming nagging parent of a physics student who has not done his homework in a modern opera called "St Mary's". In one of the scenes, the soprano (parent) is required to sing so loud that a crystal wineglass sitting on a shelf explodes.

a) What is the best frequency for the singer to sing at in order to break the wine glass with minimum effort? Why?

(2 marks)

The natural frequency of the glass. *(1)*

The glass will resonate and flex more to its natural frequency.

The flexing of the glass is what causes the glass to break. *(1)*

b) For the glass to break it must absorb 1.00×10^{-3} J of energy each second over its surface area of 75.0 cm^2. The loudest sound that the opera singer can produce at any frequency is 125 dB when measured at a distance of 1.00 m from her. An exploding wine glass can throw shards of glass up to 3 m. Calculate the maximum distance from the glass that the opera singer can stand to vocally break the glass and so decide if she needs safety glasses?

(3 marks)

Calculate power in the wave

$P = I \times A$
$L \rightarrow I = 3.16\ W / m^2$
$A = 4 \pi r^2$

$A = 4 \times 3.142 \times 1^2$

$A = 12.568\ m^2$

P = 39.7 W ***(1)***

Calculate intensity at the surface of glass required to break it.

$I = P / A$
$I = 1 \times 10^{-3} / 75 \times 10^{-4}$

$I = 1.3 \times 10^{-1}\ W / m^2$ ***(1)***

Calculate radius of area around the singer on the edge of which the glass is positioned.

$A = P / I = 39.7 / 1.3 \times 10^{-1} = 2.98 \times 10^2\ m^2$. *Working backwards produces a radius of* ***4.87 m.*** ***(1)***
Therefore…no safety glasses required.