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NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3 Physics, 2014

91523 Demonstrate understanding of wave systems

2.00 pm Tuesday 25 November 2014
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of wave systems.	Demonstrate in-depth understanding of wave systems.	Demonstrate comprehensive understanding of wave systems.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Make sure that you have Resource Booklet L3–PHYSR.

In your answers use clear numerical working, words and/or diagrams as required.

Numerical answers should be given with an SI unit, to an appropriate number of significant figures.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–8 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement

TOTAL 11

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QUESTION ONE: THE SEA ORGAN

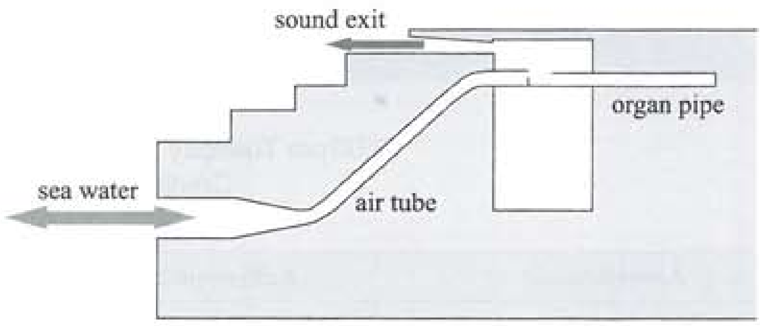
The Sea Organ in Zadar, Croatia, is a musical instrument that creates its musical notes through the action of sea waves on a set of pipes that are located underneath the steps shown in the picture. The sound from the pipes comes out through the regular slits in the vertical part of the top step.

For copyright reasons, this image cannot be reproduced here.

http://travelforsomeday.wordpress.com/2012/03/06/the-sea-organ-morske-orgule-zadar-croatia/

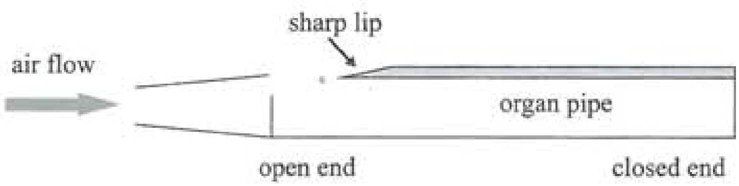
To produce a sound, the organ pipes must have air blown into them, so each organ pipe is connected to the top end of a tube, as shown in the diagram on the right.

The action of the waves pushes water in and out of a tube, creating a flow of air at the upper end of the tube.



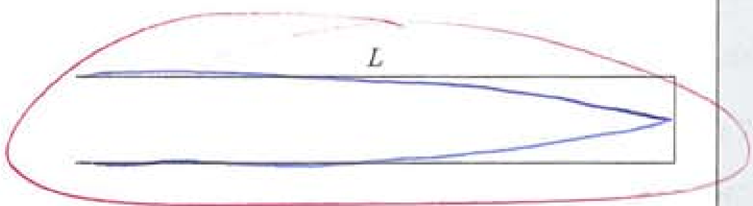
The diagram on the right shows the inside of an organ pipe.

These organ pipes have one closed end.



(a) Calculate the length, L, of an organ pipe, with one closed end, that produces a fundamental standing wave of wavelength 2.60 m.

You may find the diagram on the right useful.



$\frac{2.6}{4} = 0.65\text{m}$

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(b) Air is driven against a sharp lip, producing oscillations in the air, with a range of frequencies.

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Explain why not all frequencies produce standing waves in the pipe.

Because the pipe can only contain a ~~cont whole~~ whole number of ~~numbers~~ 1/4 wavelengths as the organ pipe has an ~~ch~~ open/closed system so only the 1st, 3rd, 5th ... harmonics are heard, only odd number harmonics produced as open/closed

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(c) The Sea Organ contains organ pipes of several different lengths.

Explain why the differences in length of the organ pipes affect the sounds that are heard.

$f = \frac{v}{\lambda}$, as the length of the pipe increases, the λ ~~[illegible]~~ increases and as the λ increases, the frequency decreases as long as the wave velocity is kept constant, a higher frequency produces a higher pitched note

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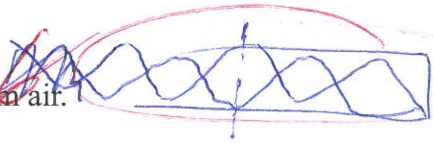
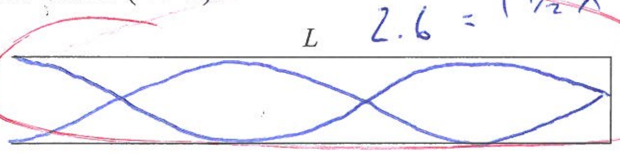
(d) The speed of sound in cold air is slower than it is in warm air.



Calculate the difference between the 3rd harmonic frequency (1st overtone) heard in summer (35°C), and the 3rd harmonic frequency heard in winter (–2°C).

Speed of sound in air at 35°C = 353 m s^{-1}
Speed of sound in air at –2°C = 330 m s^{-1}

You may find the diagram on the right useful.



~~$f_{35} = v/\lambda = 353/(\frac{4\times2.6}{5}) = 353/2.08$~~
~~$f = 169$ ... 170 Hz~~

$f_{35°C} = v/\lambda$
$= 353 \times (\frac{4\times2.6}{5})$
$= 353/2.02$
$= 170$ Hz

$f_{-2°C} = v/\lambda$
$= 330/2.08$
$= 159$ Hz

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frequency of 3rd harmonic higher in air temp of 35°C than -2°C, frequency diff of 11 Hz

A4

QUESTION TWO: INTERFERENCE

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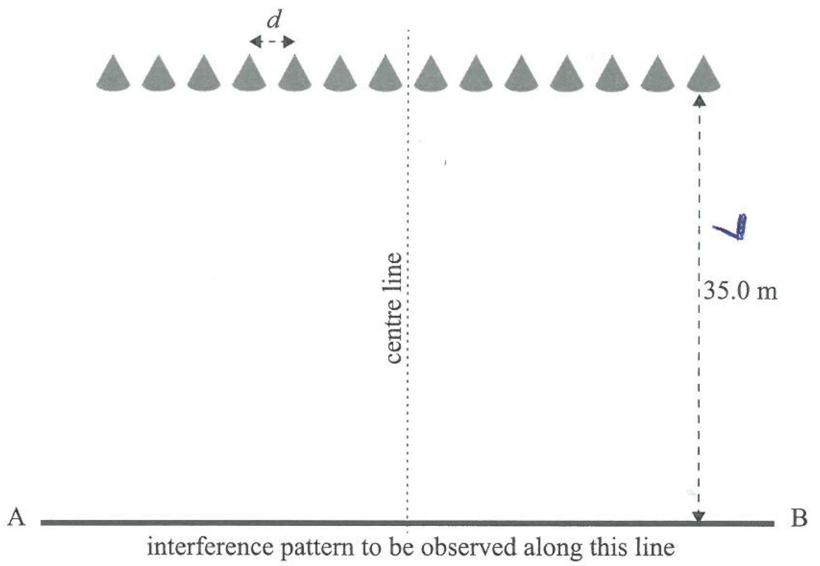
The diagram shows a series of speakers connected together, and to a frequency generator producing a single frequency. The speakers act like a diffraction grating.



(a) The sound wave source is producing a note of wavelength 0.600 m.
The distance between the speakers and the line AB is 35.0 m.
When a person walks along the line AB, the distance between two loud positions is 7.40 m. x

Calculate the separation of the speakers, *d*.

$n\lambda = \frac{dx}{L}$

$0.6 = \frac{d \times 7.4}{35}$

$\frac{21}{7.4} = \frac{d \times 7.4}{7.4}$

~~d = 2.8 m~~

$d = 2.84\,m$

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(b) Explain how the path difference of the waves causes positions of constructive and destructive interference along the line AB.

Sound is heard.

when waves arrive inphase an antinode is produced as either two crests or two troughs have ~~affect~~ interferred to produce a large crest or ~~two~~ trough respectively, this is called constructive interference - waves arrive inphase ~~at spacing~~ on whole λs. Constructive interference occurs when waves arrive out of phase by ½ a λ so a crest meets a trough so a node is produced where no sound is heard.

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(c) Explain the effect on the interference pattern of reducing the distance between the speakers.

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The ~~fr~~ fringe pattern will increase, the distance AB will increase if the speakers are ~~brought~~ moved closer together.

(d) The frequency generator is now set so that several different frequencies are emitted by each speaker.

Explain how the sound heard by someone walking along AB would differ from that described in part (b) of this question.

Please read through scribbles aswell, sorry!!

Seen

~~Beats would be heard. Beats occur when waves of different frequencies interfere with eachother. They would hear a frequency that got louder and softer as the beats were heard. When waves of different frequencies arrive inphase, a loud sound is heard, when they arrive out of phase, a quite not is heard, the beat frequency is the difference between the frequency of both of the waves and is heard when they interfere.~~

differring frequencies so differring wavelengths so there would not be ~~so~~ many nodes or antinodes, there would be a lot more interference between waves ~~as~~ as each wave will have a different frequency and wavelength so beats may be heard,

A3

QUESTION THREE: THE DOPPLER EFFECT

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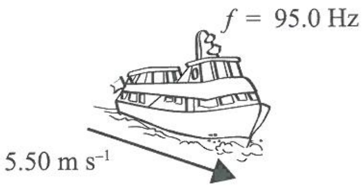
A tourist is watching a ferry boat coming towards her. The speed of the ferry is 5.50 m s^{-1}. The ferry sounds its horn, producing a note of frequency 95.0 Hz.

f V_s

The speed of sound in the air over the water is 3.50 × 10^2 m s^{-1}.

V_w



(a) Calculate the frequency of the note that the tourist hears.

$$f' = f\,\frac{V_w}{V_w - V_s} \qquad f' = 96.5\text{ Hz}$$ A

$$f' = 95 \times \frac{350}{350 - 5.5}$$

frequency heard is higher

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(b) Explain why the sound of the horn heard by the tourist does not have the same pitch as the sound emitted by the horn.

Because as the ferry is travelling ~~to~~ towards her, the ~~wavelengths~~ waves being produced by the ferry are "catching up" to waves ~~lengths~~ that already been produced so the λ is effectively shortened so $f = \frac{V}{\lambda}$ if λ decrease, frequency must increase so the tourist hears a higher frequency A

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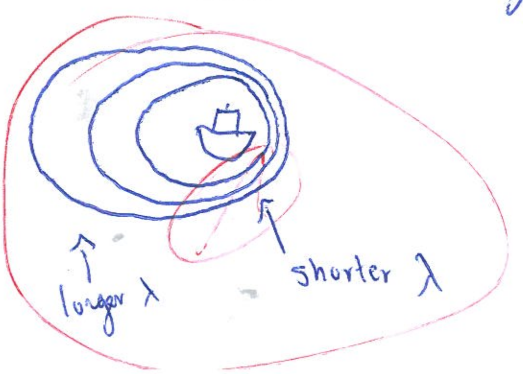

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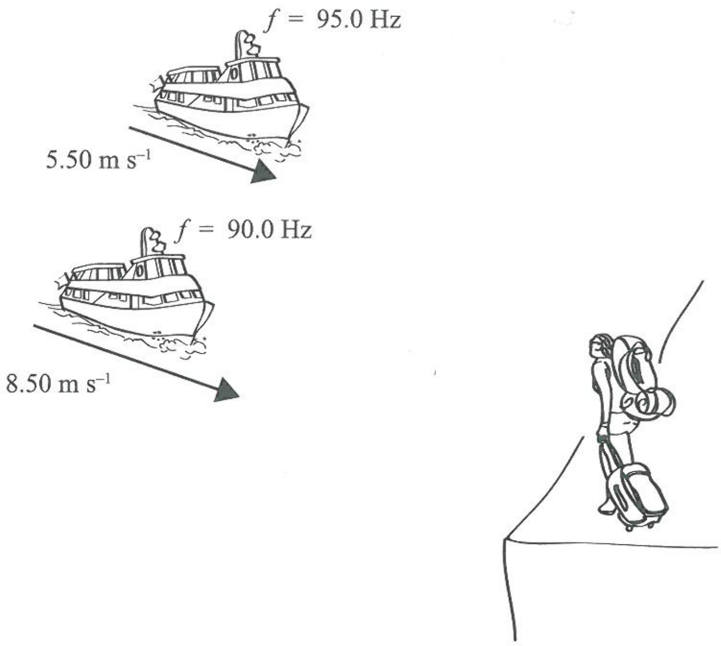

(c) A second ferry, which is overtaking the first, also sounds its horn, producing a note of frequency 90.0 Hz. For a few moments, both ferries are the same distance from the tourist, quite close together, and both are sounding their horns. The tourist hears beats.

(i) Calculate the frequency of the beats that are heard by the tourist.

95Hz - 90Hz = 5Hz beat of 5Hz

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(ii) Describe what beats are, and explain how they are created.

Beats are produced when waves of different frequencies interfere with eachother. The beat frequency is 5Hz, so they would hear a 5Hz beat as the two waves interfere. When ~~they~~ waves are inphase, a loud sound is heard and when they are out of phase, a soft sound is heard
S heard at a frequency of 5Hz

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Extra paper if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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Achieved exemplar for 91523 2014		Total score	11
Q	**Grade score**	**Annotation**	
1	A4	Part (b) correctly states that only odd harmonic frequencies resonate in the pipe, but should say that this will mean an “odd number” of ¼ wavelengths are required, instead of a “whole number”. There is no reference to how this would position an antinode at the open end of the pipe. The answer to part (c) shows understanding that the pipe length is proportional to wavelength and that the frequency will decrease as the wavelength increases. In part (d) the candidate has attempted to find the second overtone rather than the first overtone frequencies as required. They have incorrectly substituted the wavelength from part (a) in place of the pipe length.	
2	A3	A supplied formula is has been used to find an approximate answer for the distance between the speakers. A more accurate method would have required finding the angle between antinodal lines and using $n\lambda=d\sin\theta$. The answers to part (b) would have been Merit had the references to whole wavelengths and half wavelength stated that this must be the path difference.	
3	A4	The explanation for the Doppler effect correctly describes a decreased wavelength, but incorrectly attributes the changed wavelength to waves “catching up” with previously produced waves. The diagram shows some general understanding without being detailed enough to explain the situation described in the question. The beat frequency found would be correct if the ferries were not moving. Beats are recognised as being due to two waves with different frequencies interfering as they move in and out of phase. The answer needs to explain the type of interference that occurs when the waves are in and out of phase.	