Christ Church Grammar School

Science Department
Year 11 2020

ATAR PHYSICS
WAVES
TEST 2020

Student Name: **SOLUTIONS**

Teacher: JRM PCW CJO SA
(Please circle)

Time allowed for this paper
Working time for paper: 50 minutes.

Instructions to candidates:

- You must include **all** working to be awarded full marks for a question. Answers should be expressed to 3 significant figures unless otherwise indicated.
- Marks may be deducted if diagrams are not drawn neatly with a ruler and to scale (if specified).
- Marks will be deducted for incorrect or absent units.
- **No** graphics calculators are permitted – scientific calculators only.

Additional Formulae:

Surface area of sphere:
$SA = 4\pi r^2$

Intensity:
$I = \frac{P}{A}$

Path Difference:
$n\lambda = |L_1 - L_2|$

Mark:	/ 45
=	%

Question 1 **(11 marks)**

Under high wind conditions, a particular handrail starts to vibrate. The engineers tasked with fixing this problem note that the vibration can be heard and determine that the resulting sound waves have a frequency of 302 Hz. The handrail is fixed at both ends.

(a) Calculate the wavelength of the sound waves if this occurs on a 25˚C day.

(2 marks)

Description	Marks
$\lambda = \frac{v}{f} = \frac{346}{302}$	1
λ = 1.15 m	1
Total	2

(b) Explain, using relevant scientific terms, why the situation occurs and propose one solution to fix the problem.

(4 marks)

Description	Marks
Force is applied to handrail by wind (driving frequency) causing handrail to vibrate at natural frequency.	1
Wind continues to force vibration in phase	1
This results in rapid increase in amplitude	1
Propose solution: 1. Change handrail – material, length, size 2. Stop the source – block the wind	1
Total	4

The engineers measure the length of handrail to be 2.30 m.

(c) Calculate which harmonic this handrail is vibrating at.

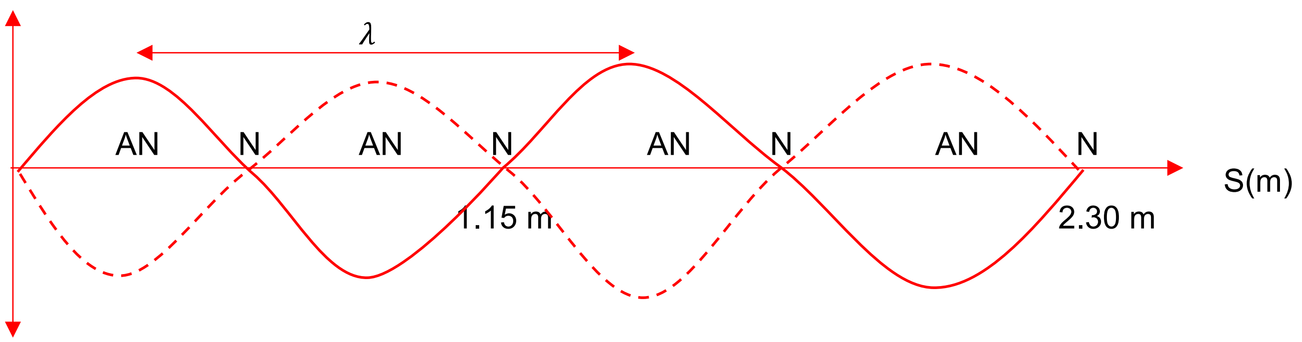
(2 marks)

Description	Marks
$\frac{L}{\lambda} = 2$	1
4th Harmonic	1
Total	2

(d) Draw a displacement - distance graph of this wave, labelling all relevant dimensions.

(3 marks)

Description	Marks
Shape is accurate	1
Both ends are at zero displacement	1
Wavelength is noted	1
Total	3

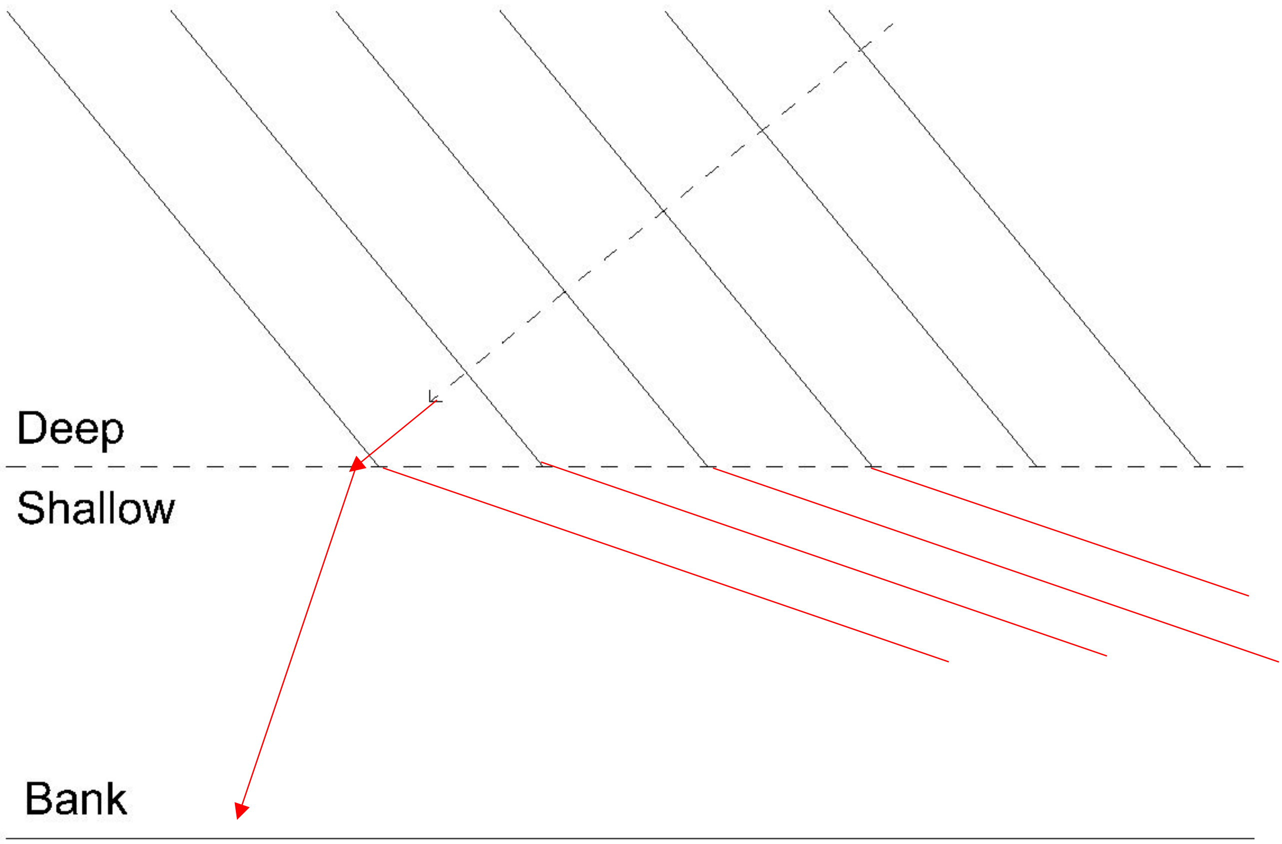


Question 2 **(6 marks)**

A boat travels down the Swan River and creates a set of small waves referred to as wake. The boat is travelling in deep water but the waves are propagated toward the bank where the depth is shallower. In shallow water, the wave speed decreases.

(a) Complete the diagram below to show what the waves would look like at the crossing between the deep and shallow water sections.

(3 marks)



Description	Marks
Waves bend away from the normal	1
New wave fronts are parallel	1
Direction of wave propagation is shown	1
Total	3
If refracted the wrong way; maximum 2 marks	

A careless passenger on the boat throws a paper cup overboard. He watches the cup as the wake travels past it and notices that the cup only moves up and down.

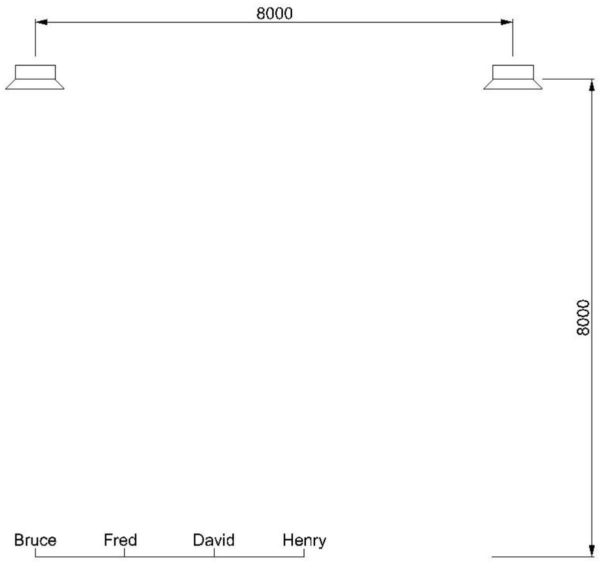
(b) State and explain which type of mechanical wave it is, and explain the difference between the two main types of waves.

(3 marks)

Description	Marks
Wave is transverse	1
Particles are moving up and down, therefore perpendicular to direction of propagation	1
In a longitudinal wave, particles move parallel to direction of propagation	1
Total	3

Question 3 **(6 marks)**

A group of sound technicians are testing a new sound system for a concert. Using a signal generator, they are testing a specific frequency of 155 Hz. A speaker is situated at each end of the stage which makes them 8.00 m apart at their centres. The technicians stand at the back of the room, 8.00 m from the stage. They are socially distancing and are therefore 1.45 m apart. Bruce is standing directly in front of the left speaker. Dimensions in the diagram are provided in millimetres. Assume that the speed of sound is 341 m s^{-1}



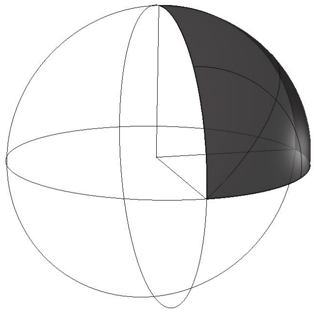
Determine if Bruce and Fred experience constructive or destructive interference.

(6 marks)

$\lambda = \frac{v}{f}$ $\lambda = \frac{341}{155}$ λ = 2.2 m	1
Bruce:	
Speaker 2 distance = $\sqrt{8^2 + 8^2} = 11.3\ m$	1
PD = 11.3 – 8 = 3.3 m - nλ	0.5
$\frac{3.3}{2.2} = n = \frac{3}{2}$ = half integer therefore destructive	0.5
Fred:	
Speaker 1 distance = $\sqrt{8^2 + 1.45^2} = 8.13\ m$	1
Speaker 2 distance = $\sqrt{8^2 + 6.55^2} = 10.3\ m$	1
PD = 10.3 – 8.13 = 2.17m	0.5
$\frac{2.17}{2.2} = n \approx 1$. Whole integer therefore constructive	0.5

Question 4 **(8 marks)**

Megaphones are often designed to have a very targeted area for the sound to travel. The end cone of a megaphone allows sound only to travel through an angular sector of 90.0 degrees in both the vertical and horizontal planes. A particular megaphone has a power rating of 80.0 W and an efficiency of 42.0 %.



(a) If a bystander is standing 4.50 m away from the megaphone, calculate the sound intensity.

(4 marks)

P = 80.0 x 0.42 = 33.6W	0.5
A = $\frac{1}{8} \times 4\pi r^2$	0.5
I = $\frac{P}{0.5 \times \pi \times r^2}$	1
$I = \frac{33.6}{0.5 \times \pi \times 4.5^2}$	1
I = 1.06 Wm^{-2}	1

(b) Calculate the distance that you would need to stand away from a larger megaphone with a power rating of 204 W to experience that same sound intensity. If you could not complete part (a), use I = 1.16 Wm^{-2}.

(4 marks)

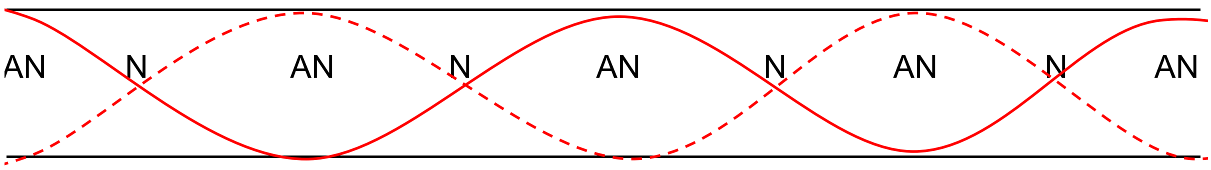
P = 204.0 x 0.42 = 85.7W	0.5
I = $\frac{P}{A}$,	0.5
$r^2 = \frac{P}{0.5 \times \pi \times I}$	1
$r^2 = \frac{85.7}{0.5 \times \pi \times 1.06}$	1
r = 7.17 m (6.86 m)	1

Question 5 **(7 marks)**

A marimba is a musical instrument with resonant pipes underneath each note. Each pipe is tuned for the fundamental frequency, the fourth harmonic and the tenth harmonic. Resonant pipes are open at both ends.

(a) Draw the standing wave (displacement – distance) of the fourth harmonic. Label each displacement node and antinode.

(2 marks)



Shape	1
All nodes and anti-nodes labelled	1

(b) One of the longer pipes is 1.22 m long. Calculate the frequency of the lowest note produced by this pipe when the air temperature is 25.0° C.

(2 marks)

$f = \frac{v}{2L}$	1
$f = \frac{346}{2 \times 1.22}$ = 142 Hz	1

When constructing this instrument, a tuning fork was used to ensure that the frequencies matched a specific note. Initially, a note was played on the marimba and 6 beats per second were heard with a tuning fork of 639 Hz. The pipe was then shortened until the beats were no longer heard.

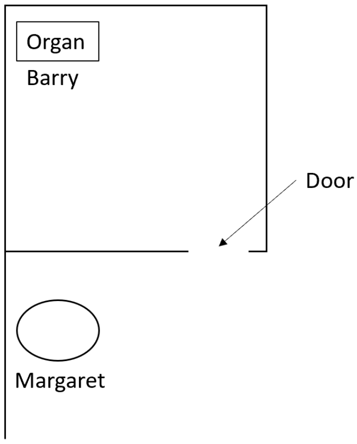
(c) Calculate, with reasoning, the initial frequency of the note that was played.

(3 marks)

If pipe is shortened L decreases, λ is decreased and f is increased as $f = \frac{nv}{2L}$ or $\lambda = \frac{2L}{n}$	1
Fbeat = 6 hz = 639 - f	1
F = 633 hz	1

Question 6 **(7 marks)**

Barry and Margaret are both sitting at home. Barry has an organ in his room and Margaret is reading in the corner of the courtyard outside. The door to Barry's room is open. When playing certain notes, Margaret can hear the organ loudly but with other notes, she hears a quieter sound. The air temperature is 25.0° C.



(a) State what this phenomenon is called and explain the situation above.

(3 marks)

Diffraction	1
Waves are able to bend around obstacles	1
Only when the wave length is greater than the size of the obstacle	1

(b) If the door is 1.00 m wide, calculate the range of frequencies that Margaret will likely hear loudly and the range of frequencies that she will hear softly.

(4 marks)

$v = f\lambda$	1
$f = \frac{v}{\lambda} = \frac{346}{1.00} = 346Hz$	1
Frequencies above 346 have lower wavelength and are soft	1
Frequencies below 346 have higher wavelength and are loud	1

END OF TEST