

# 3

91523



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## Level 3 Physics, 2015

### 91523 Demonstrate understanding of wave systems

9.30 a.m. Friday 20 November 2015  
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.**

**TOTAL**

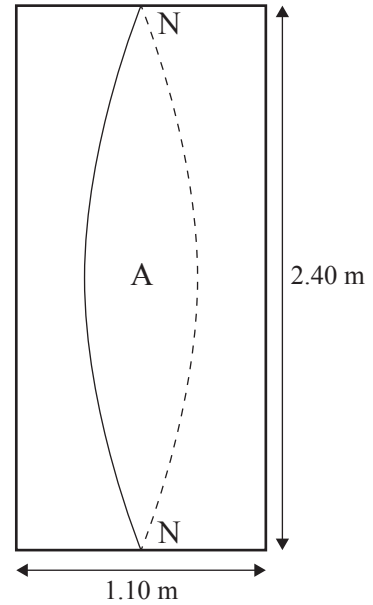
ASSESSOR'S USE ONLY

**QUESTION ONE: STANDING WAVES AND PLUMBING**

Speed of sound in air =  $3.43 \times 10^2 \text{ m s}^{-1}$

Speed of sound in water =  $1.49 \times 10^3 \text{ m s}^{-1}$

A shower acts like a closed pipe with a node at both ends. Matthew's shower has a height of 2.40 m, with a square base of width 1.10 m. The diagram shows a side view of the shower with one of the standing sound waves that can be set up in the shower. The displacement antinode (A) and nodes (N) are shown on the diagram.



- (a) Show that the frequency of the vertical standing sound wave drawn is 71.5 Hz.

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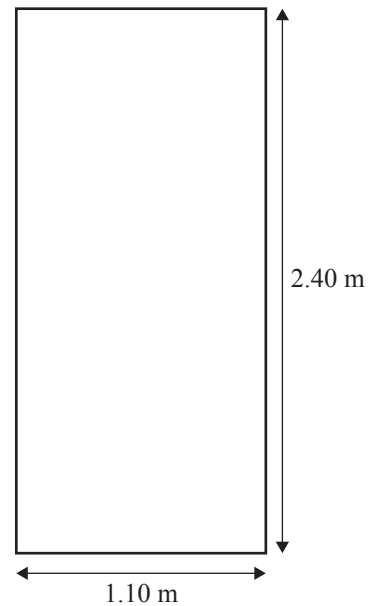
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- (b) Matthew loves singing in the shower. Although Matthew is a talented singer he cannot sing a note to resonate at this low a frequency. However, Matthew can produce two resonant frequencies:

- a vertical standing wave at 143 Hz
- a horizontal standing wave at 156 Hz.

Draw these two standing waves in the box on the right.

Show the calculations you used, in order to draw the two waves.




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- (c) One day, Matthew finds his shower is filling with water because the shower waste pipe is blocked. Matthew drains water from the waste pipe, and attempts to locate the position of the blockage.

With a loudspeaker, Matthew detects the fundamental frequency, and then detects the next two adjacent resonant frequencies at  $1.80 \times 10^2$  and  $3.00 \times 10^2$  Hz. Matthew uses these resonant frequencies to estimate that the pipe is blocked 1.43 m from the open end.

Show how Matthew calculated that the pipe is blocked 1.43 m from the open end.

You may want to draw waveforms in the diagrams below to help you.




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- (d) With the loudspeaker still set at  $3.00 \times 10^2$  Hz, Matthew fills the waste pipe with water. He uses his loudspeaker to make sound waves in the water, and puts his ear in the water and listens, but the sound no longer resonates.

Calculate one of the frequencies that Matthew should set the loudspeaker to in order to get resonance again.

In your answer you should:

- describe how the water affects the speed of the sound wave
- explain why the sound in the waste pipe no longer resonates at  $3.00 \times 10^2$  Hz
- calculate one of the resonant frequencies.

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**QUESTION TWO: INTERFERENCE**

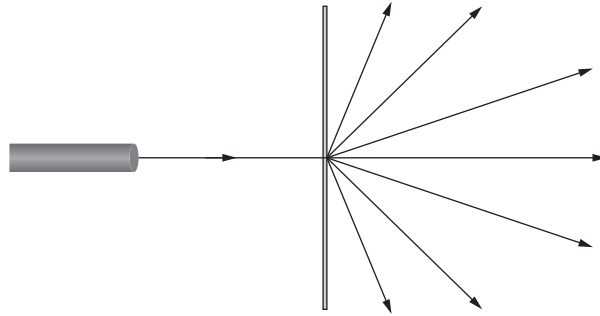
Rianne uses a pair of novelty glasses to produce a laser show.

When she shines a laser through the centre of one of the eyepieces, the laser light splits up into a number of beams.

She suspects that the novelty glasses contain a diffraction grating.

Rianne measures the angle between the bright central beam of light and the 1st order maximum in the horizontal direction to be  $26.0^\circ$ .

The laser light has a wavelength of  $532 \times 10^{-9}$  m.



- (a) Calculate the slit spacing of the novelty glasses.

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- (b) Rianne experiments by shining her laser light through different parts of the glasses. There are more lines per metre in the middle of each eyepiece (smaller slit spacing) than there are at the edges.

Describe the differences in the patterns Rianne would see when she shines the laser light through the two different sections of the glasses.

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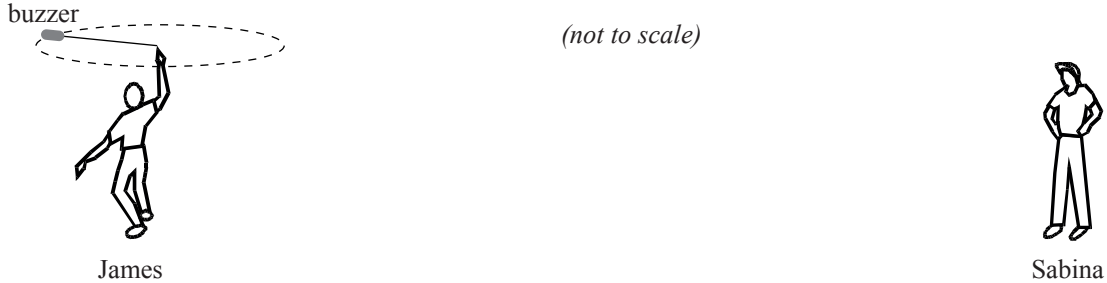
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**QUESTION THREE: THE WHIRLING BUZZER**

Speed of sound in air =  $3.43 \times 10^2 \text{ m s}^{-1}$

James attaches a buzzer to the end of a piece of string. James whirls the buzzer above his head in a horizontal circle of radius 1.02 m at a constant speed of  $16.0 \text{ m s}^{-1}$ .



Sabina stands a long distance away and listens.

- (a) Describe the motion of the buzzer when Sabina receives sound waves with the shortest wavelength.

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- (b) If the frequency emitted by the buzzer is 512 Hz, show that the lowest frequency heard by Sabina is 489 Hz.

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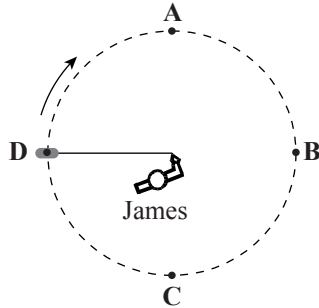


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- (c) Sabina stands a very long way away from James and listens to the buzzer. The sound appears to be increasing in frequency as the buzzer travels from point C to point A.

Explain why Sabina hears an increasing frequency between point C and point A.

*You may want to use calculations to assist your answer.*



(not to scale)

Sabina

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- (d) James wants Sabina to hear beats. He puts a second buzzer, which is also emitting a sound of frequency 512 Hz, on the ground. James again whirls the original buzzer above his head, but at a different speed. When the buzzer is at point A, James lets go of it, so the buzzer flies towards Sabina.

Sabina hears a 10 Hz beat as James releases the string.

Calculate the velocity of the buzzer at the point of release.

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