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Level 3 Physics, 2017

91523 Demonstrate understanding of wave systems

2.00 p.m. Monday 20 November 2017
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 2–11 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

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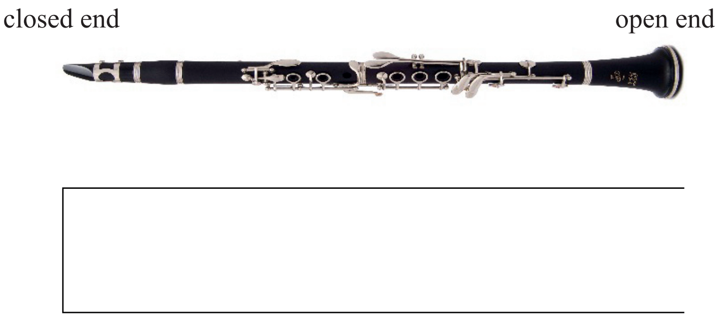
QUESTION ONE

In 1845, Dutch physicist Buys Ballot demonstrated the Doppler effect by listening to musicians playing their instruments on a train as it passed by him.

One musician played a note on a clarinet with all the finger holes closed. A clarinet can be modelled as a pipe that is open at one end and closed at the other. The length of the clarinet is 0.613 m.

The speed of sound is 341 m s^{-1}.

(a) On the diagram below, draw the 1st harmonic (fundamental) standing wave, AND label the nodes and antinodes.



If you need to redraw your response, use the diagram on page 8.

(b) The clarinet produces the fundamental frequency and several harmonics.

Explain why the clarinet does not produce any even harmonics.

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(c) When the train was approaching Ballot at a speed of 5.00 m s^{-1}, he heard a frequency of 139 Hz from the clarinet.

Show that the frequency of the sound heard by the clarinet player would have been 137 Hz.

(d) A second clarinet player was standing beside Ballot as the train approached. She produced the same frequency (137 Hz) as the clarinet player on the train, causing Ballot to hear beats.

Explain why the sound wave reaching Ballot from the clarinet on the train did not have a frequency of 137 Hz, AND explain why Ballot heard beats, AND calculate the beat frequency.

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QUESTION TWO

Mike and Kate are on a tramping trip and are crossing a suspension bridge. They realise that by jumping up and down in a particular way, they can set up a standing wave in the bridge. The bridge is 24.0 m long.

(a) Describe one difference between a standing wave and a travelling wave.

(b) A bridge can oscillate at many harmonics.

Show that the frequency of the 3rd harmonic mode is: $f = \dfrac{3v}{2L}$, where L is the length of the bridge.

(c) The bridge oscillates at the fundamental frequency mode with a period of 1.80 s.

Calculate the speed of the waves in the bridge.

(d) Mike is 6 m from one end and Kate is 6 m from the other end.

Give a comprehensive explanation of how it is possible for Mike and Kate to cause the bridge to oscillate in the 2nd harmonic mode.

In your explanation you should:

- draw a labelled diagram of the bridge oscillating in the 2nd harmonic mode
- explain how they set up a standing wave
- explain why they choose to stand in the positions stated
- explain the phase relationship between their oscillations.

If you need to redraw your response, use the box on page 8.

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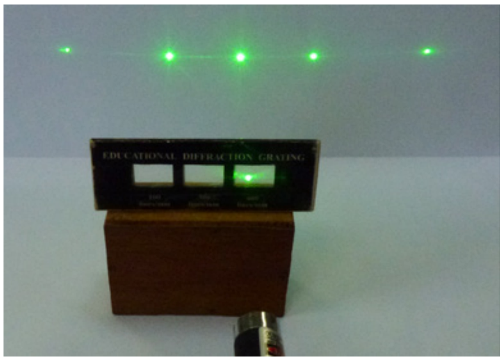
QUESTION THREE



Priya wants to measure the wavelength of her green laser. She shines the laser beam through a diffraction grating. She sees an interference pattern on the wall behind the diffraction grating, as shown in the photograph.

The slits in the diffraction grating are 2.00×10^{-6} m apart.

The angle between the central anti-nodal line and the first anti-nodal line is 15.4°.

(a) Show that the wavelength of the green laser is 5.31×10^{-7} m.

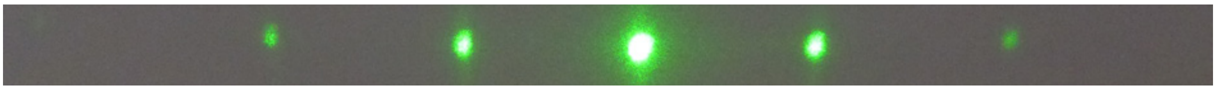
(b) Explain what causes the bright spot at the first antinode (first order maximum).

(c) The picture at the top of page 7 shows the pattern she sees using the green laser.

Priya repeats the experiment using a red laser (red light has a lower frequency than green light).

Draw the pattern she would expect to see with the red laser.

Explain why this pattern is different to the green laser.



If you need to redraw your response, use the box on page 8.

(d) Priya shines white light through another diffraction grating. There are three complete spectra of visible light produced each side of the central antinodal line.

Calculate the minimum slit separation on this diffraction grating.

Explain your reasoning.

The frequency of violet light is 7.70×10^{14} Hz.

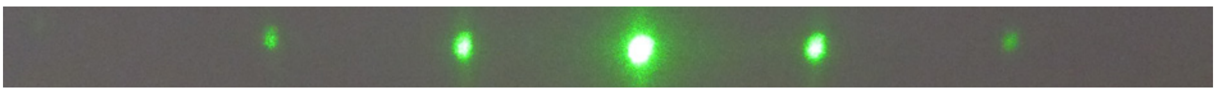
The frequency of red light is 4.30×10^{14} Hz.

SPARE DIAGRAMS

If you need to redraw your response to Question One (a), draw it on the diagram below. Make sure it is clear which answer you want marked.

If you need to redraw your response to Question Two (d), draw it in the box below. Make sure it is clear which answer you want marked.

If you need to redraw your response to Question Three (c), draw it in the box under the diagram below. Make sure it is clear which answer you want marked.



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

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