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Level 3 Physics, 2018

91523 Demonstrate understanding of wave systems

2.00 p.m. Tuesday 20 November 2018
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 2–12 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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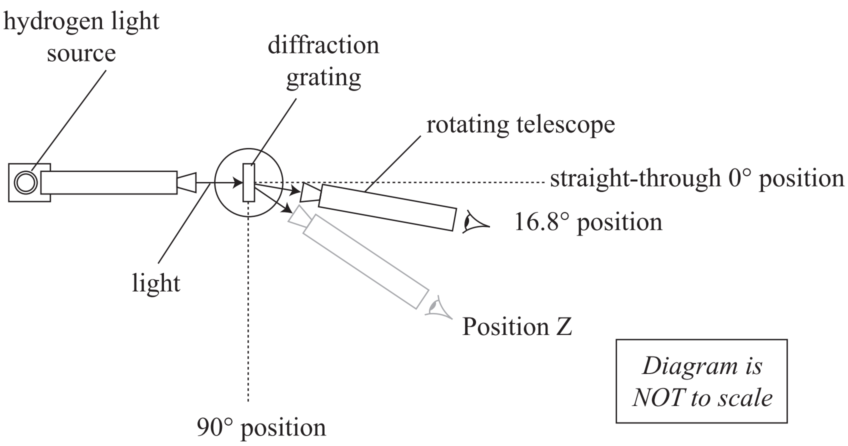
QUESTION ONE

All elements emit a number of distinct fixed wavelengths of light known as spectral lines that are unique to each element. Hydrogen emits four visible light lines, as shown below.

The Visible Spectrum of Hydrogen [1 nm = 1×10^{-9} m]

https://historyoftheatomictheory.wordpress.com/activity-hydrogen-spectrum/

Light from a hydrogen source can be passed through a diffraction grating to form an interference pattern. The wavelength of each spectral line can then be determined by measuring the angle to its first order maximum.



(a) The lines on a diffraction grating are spaced 1.68×10^{-6} m apart.

Show that the wavelength of the spectral line with a first order maximum at 16.8° is 486 nm.

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(b) The telescope is rotated from the 16.8° position to Position Z, the location of the next spectral line.

State the wavelength of this line. Explain your reasoning.

(c) Calculate the maximum number of orders visible for the 656 nm line.

(d) The diffraction grating is replaced with a double-slit that has a slit separation of 1.68×10^{-6} m.

Describe and explain any changes that will occur to the location, brightness, and width of the maxima for the 656 nm line.

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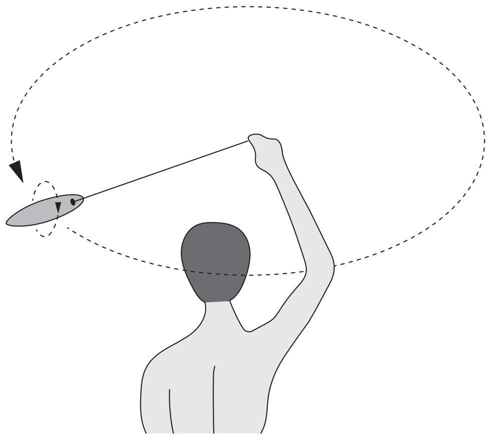
QUESTION TWO

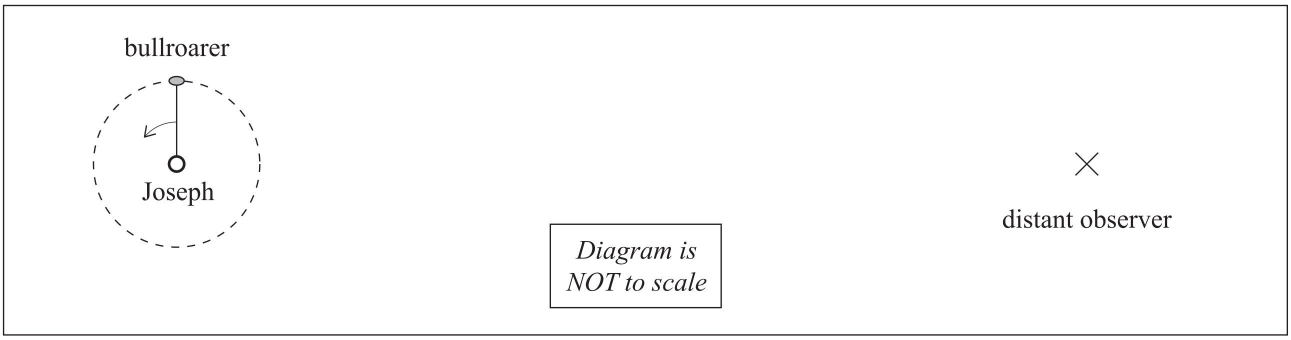
Speed of sound in air = 344 m s^{-1}

A bullroarer is a carved piece of wood attached to a string. It can be swung around the head to create sounds that travel long distances and fluctuate in pitch. The user can control the changes in pitch by swinging the bullroarer around in a circle at different speeds.



The bullroarer emits a note at 2.00×10^2 Hz as Joseph swings it in a circle with a period 1.00 s and speed 6.28 m s^{-1}. Joseph is at the centre of the circle.

Figure A



(a) Describe changes in sound that will be heard by a distant observer, as the bullroarer moves around the circle.

(b) When the bullroarer is at the position shown in Figure A on page 4:

(i) Calculate the wavelength of the sound waves that Joseph will hear.

(ii) Explain why the sound waves observed by the distant observer will not have the same wavelength that Joseph experiences.

(c) Clearly mark on the diagram in Figure A, the two positions of the bullroarer at which the distant observer will measure the same frequency as Joseph.

Explain why the frequency at these points is the same as what Joseph would measure.

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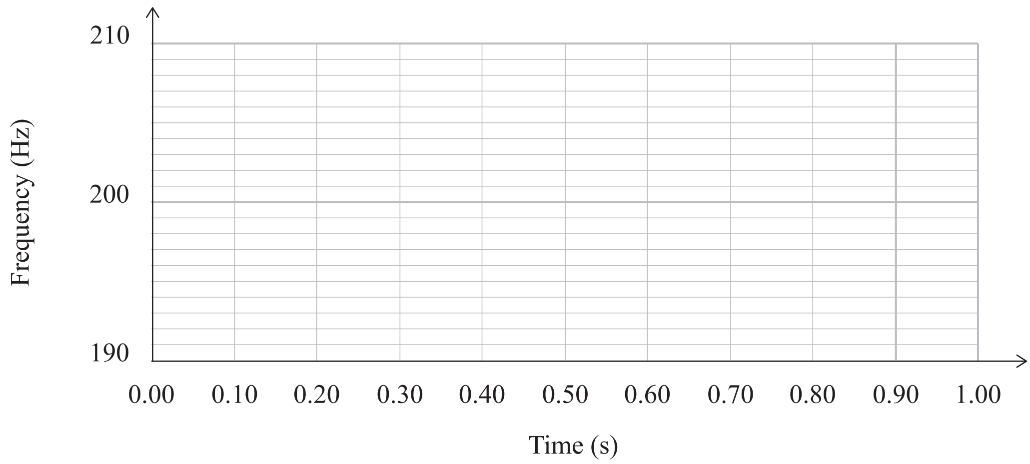
(d) Calculate the maximum and minimum frequencies that a distant observer will measure during one revolution of the bullroarer.

Use these to draw a graph of the variation of frequency against time starting from the position shown in Figure A on page 4.



If you need to redraw your response, use the box on page 10.

QUESTION THREE

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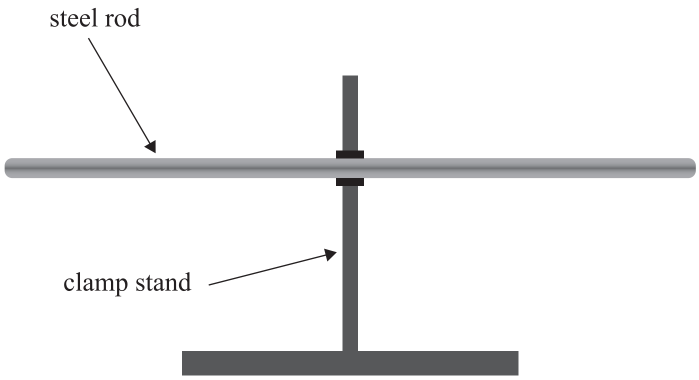
Speed of sound in air = 344 m s^{-1}

Clara wants to investigate the properties of a 0.400 m length of solid steel rod. The bar is clamped rigidly at the centre, and the ends are free to vibrate. The rod is struck in such a way as to produce a fundamental longitudinal standing wave.



(a) Show that the wavelength of the wave is 0.800 m.

A diagram should be included in your answer.

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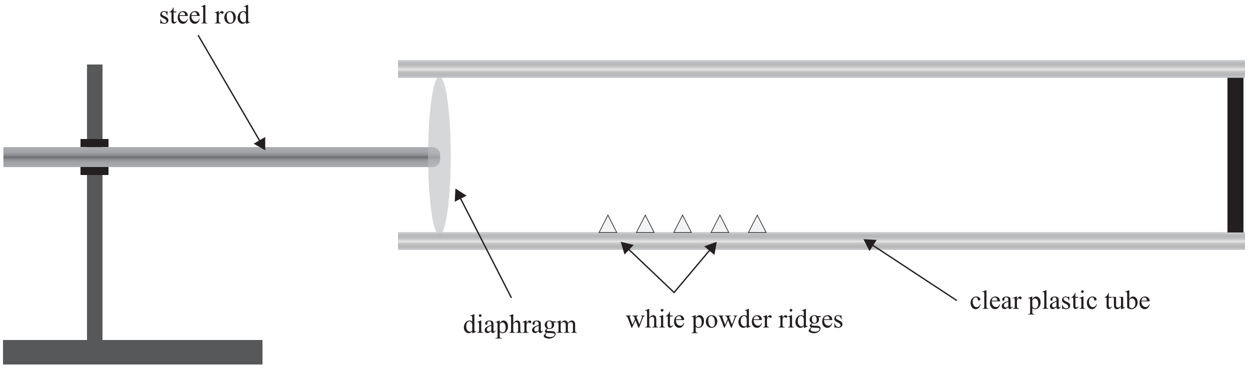
One end of the rod is attached to a diaphragm that can move freely inside a clear plastic tube. The clear plastic tube is closed at the opposite end. On the bottom of the clear plastic tube is a fine white powder.

When the steel rod is struck, the white powder forms into ridges that are $\frac{\lambda}{2}$ apart. The steel rod still vibrates at the fundamental frequency.



(b) The frequency of vibrations in the air in the tube is the same as the frequency of the vibrations in the steel rod.

Explain why this is true for the frequency, but not for the wavelength of the two vibrations.

(c) Clara measures the ridges to be 2.30×10^{-2} m apart.

Calculate the speed of sound in the rod.

(d) The clamp stand is adjusted and the steel rod is struck in such a way as to produce a standing wave of the second harmonic in the rod.

Explain the effect this will have on the air inside the tube.

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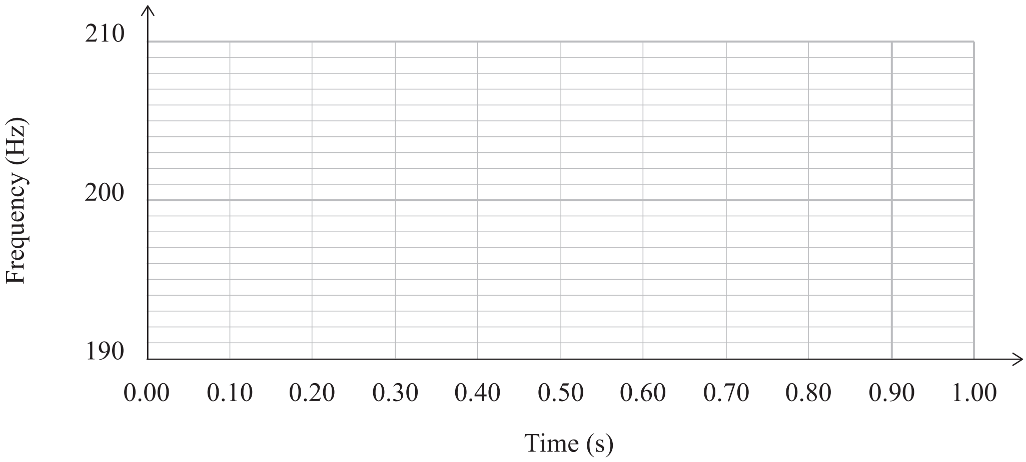
SPARE DIAGRAMS

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



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

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