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Draw a cross through the box (☒) if you have NOT written in this booklet

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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Physics 2024

91523 Demonstrate understanding of wave systems

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 appropriate SI unit.

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.

Do not write in the margins (⁄⁄⁄). This area will be cut off when the booklet is marked.

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

QUESTION ONE: THE PAN FLUTE

Speed of sound in air = 343 m s^{-1}

https://www.istockphoto.com/search/2/image-film?phrase=pan+flute

The pan flute is a wind instrument that creates sound when air is blown across it. It consists of different length pipes that are bound together. Each pipe is closed at one end and open at the other end.

(a) In the diagram below, draw a diagram of the third harmonic that can be produced in a pan flute.

Label nodes (N) and antinodes (A) in the diagram.

If you need to redraw your response, use the diagram on page 9.

(b) Jane has a pan flute. The shortest pipe is 8.50 cm long and the longest pipe is 17.5 cm long.

Calculate the frequency of the third harmonic produced in the shortest pipe.

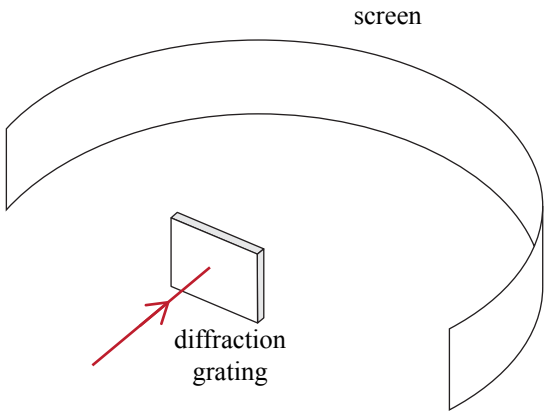
(c) Explain how standing waves are formed in a pan flute that is open at one end and closed at the other end, and explain why not all harmonics can be formed.

(d) Some pan flutes can be tuned by moving a small cork inside the pipe to adjust the length of the pipe. Initially the length of the longest pipe is too long, and the untuned pipe creates a beat of 9.00 Hz with another tuned pipe. The tuned pipe has a length of 0.164 m, which produces a frequency of 523 Hz when playing the first harmonic.

Calculate how much further the cork needs to be pushed into the pipe and explain how it is possible to hear when the cork is in the correct position.

QUESTION TWO: INTERFERENCE

Jane's Physics teacher Mr Smith shines a red laser through a diffraction grating placed at the centre of a semicircular screen. The pattern seen on the screen has a number of narrow, bright fringes.



(a) The formula associated with diffraction gratings is $n\lambda = d\sin\theta$, where n is the order number and λ is the wavelength.

What does the term $n\lambda$ represent, when n and λ are combined?

(b) The diffraction grating that was used has 200 lines per mm. The red laser used has a wavelength of 638 nm.

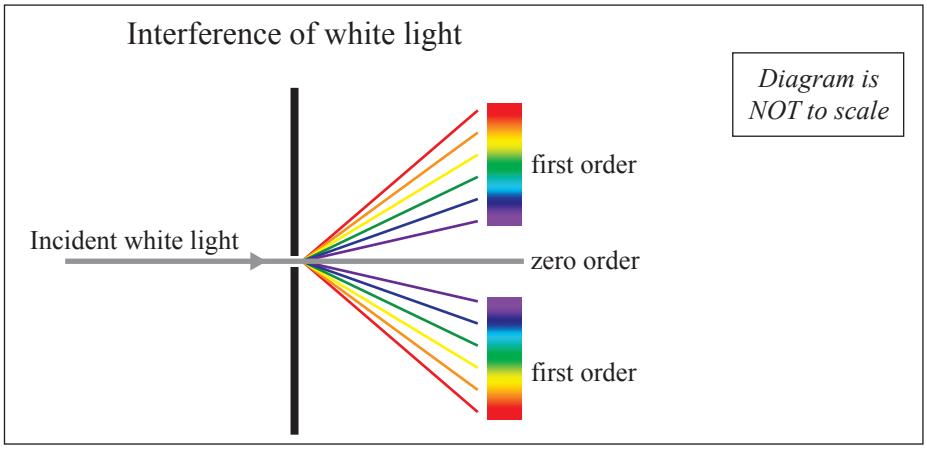
Calculate the total number of dots that are seen on the semicircular screen.

Begin your answer by calculating the distance between the slits.

(c) Mr Smith uses the same red laser and shines it through two slits where the slits are of the same width as the diffraction grating, but the slits are further apart. The pattern on the screen is different compared to the pattern obtained in a diffraction grating.

Describe the differences between the patterns formed, and explain the reason for each difference.

(d) Mr Smith then shines white light onto the diffraction grating. The pattern he observes has a central white region, and the other orders form complete spectra on either side of the central white region, as shown in the diagram below:



Explain why white light forms a spectra, with violet on the inside and red on the outside, when passed through a diffraction grating.

QUESTION THREE: DOPPLER EFFECT

Jane and her classmates stand on the platform at a railway station, listening to a train approach them at a constant speed, blowing its whistle. The speed of sound in air is 343 m s^{-1}.

www.istockphoto.com/photo/auckland-public-transport-the-eastern-line-gm1188085389-335868210

(a) Describe what Jane and her friends would hear, compared to the driver, as the approaching train blows its whistle.

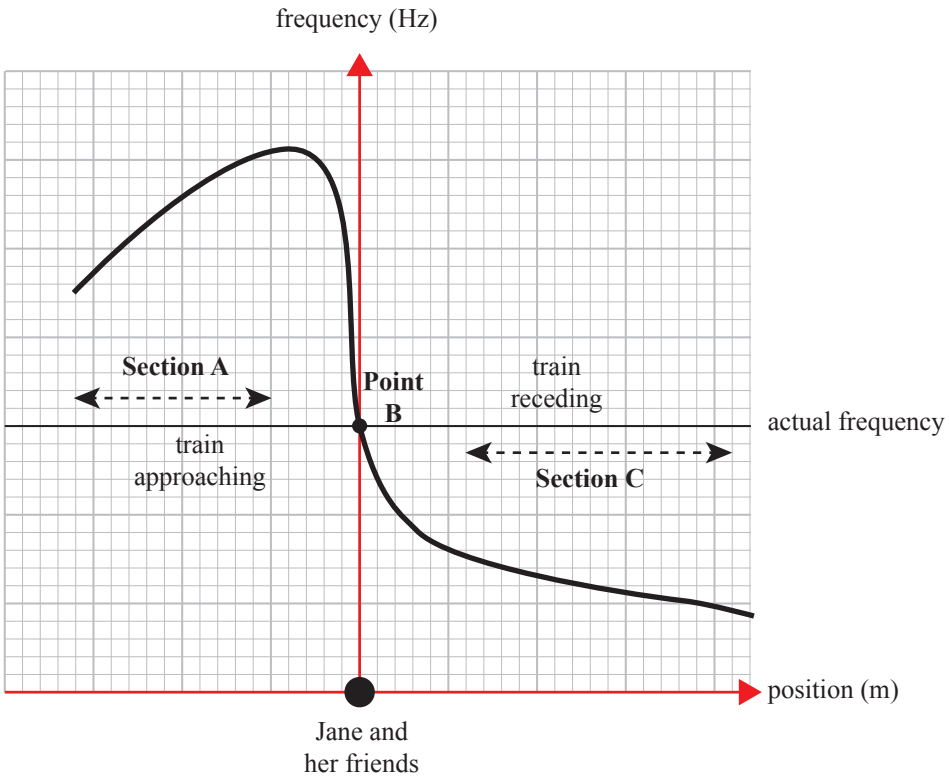
(b) Explain why Jane and her friends would hear a change in frequency as the approaching train blows its whistle.

(c) Jane and her friends hear a frequency of 1270 Hz as the train approaches them. After the train has passed them, they hear a frequency of 1190 Hz as the train goes away from them at the same constant speed.

Calculate the speed of the train.

Question Three continues on the following page.

(d) Jane and her friends listen to the whistle of another train that approaches them and then goes past them, without stopping at the station. The graph below is a frequency vs position graph for this situation.



Explain what may be happening in this situation by considering the shape of the graph in relation to frequency and position:

(i) as the train approaches (Section A).

(ii) as the train is right in front of Jane and her friends (Point B).

(iii) as the train goes away from Jane and her friends (Section C).

SPARE DIAGRAM

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

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

QUESTION NUMBER

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