91523

915230

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

3

SUPERVISOR'S USE ONLY

Level 3 Physics, 2019

91523 Demonstrate understanding of wave systems

2.00 p.m. Wednesday 20 November 2019
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.

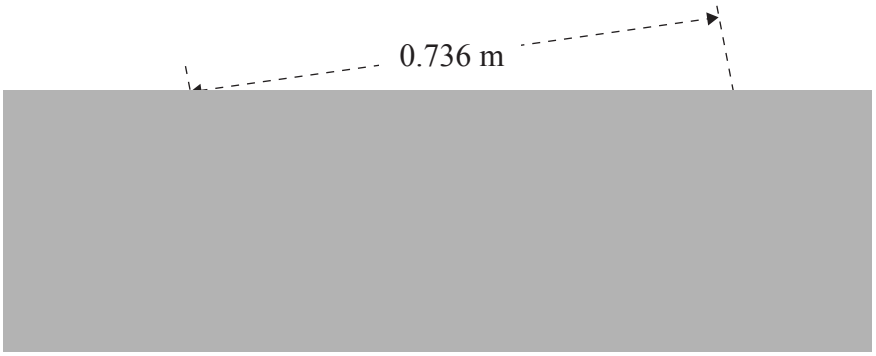
TOTAL

ASSESSOR'S USE ONLY

QUESTION ONE: HOMEMADE GUITARS

ASSESSOR'S USE ONLY

Sarah builds a simple guitar using a hollow wooden box as a resonator, and three strings on a wooden fretboard. She fixes the strings between two bridges that are separated by 0.736 m.



www.ebay.com/c/1732544785

(a) In the space below, sketch the 4th harmonic (3rd overtone) that is formed when a string is plucked.

(b) The speed of the wave through the string is 289 m s^{-1}.

Calculate the wavelength and frequency of this harmonic.

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

(c) The three strings of the box guitar produce different fundamental frequencies when played, even though the strings are the same length, and are made of the same material.

Use the equation below to explain how this is possible.

$$v_{\text{wave on string}} = \sqrt{\frac{\text{tension}}{\text{mass per unit length}}}$$

No calculations are required.

ASSESSOR'S USE ONLY

(d) Sarah wants to tune the D string to the frequency 147 Hz. She plays a 147 Hz tuning fork, then plucks the D string on the guitar. She notices a pulsating loudness twice every second. When she gradually increases the tension of the string, the pulsating loudness becomes less frequent, and then disappears.

Explain the phenomenon that causes the pulsating loudness, and why increasing the tension of the string makes it disappear.

A calculation of the original frequency of the (untuned) D string should be included in your answer.

QUESTION TWO: OPEN PIPE HARMONICS

ASSESSOR'S USE ONLY

The speed of sound in air is 338 m s^{-1}.

Sam and Miracle are experimenting with a 0.446 m length of plastic pipe that is open at both ends. When the wind blows across the top of the pipe, Sam and Miracle hear a sound. They assume the sound is made by air inside the pipe resonating at the fundamental frequency.

(a) Show that the frequency of the sound is 379 Hz.

(b) Sam places his hand over the end of the pipe, and the frequency of the sound coming out of the pipe changes.

Describe and explain the changes in the frequency of the pipe.

Draw diagrams to support your answer.

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

ASSESSOR'S USE ONLY

(c) Sam removes his hand so the pipe is open at both ends again. A strong gust of wind blows across the top of the pipe and causes a much higher pitched sound to be produced. Miracle uses an app on her phone to determine that the frequency of the sound is 1138 Hz.

Draw the new standing wave formed in the pipe on the diagram below.

Identify the harmonic that is resonating in the air column.

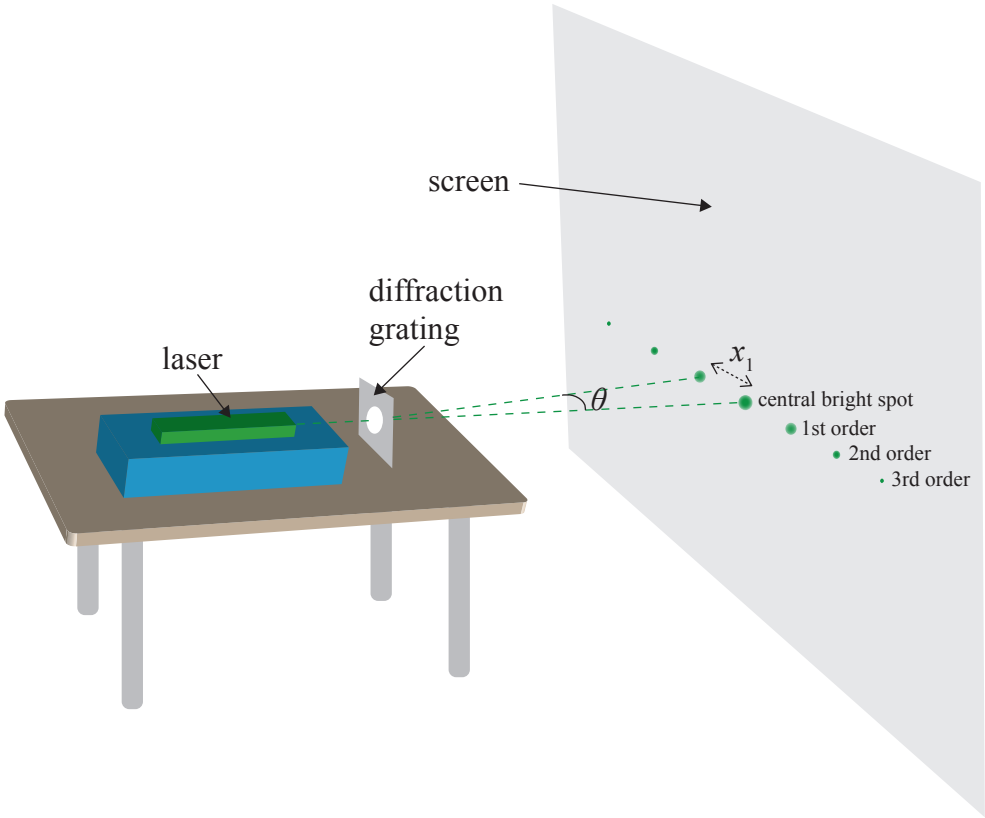
If you need to redraw your diagram, use the space on page 9.

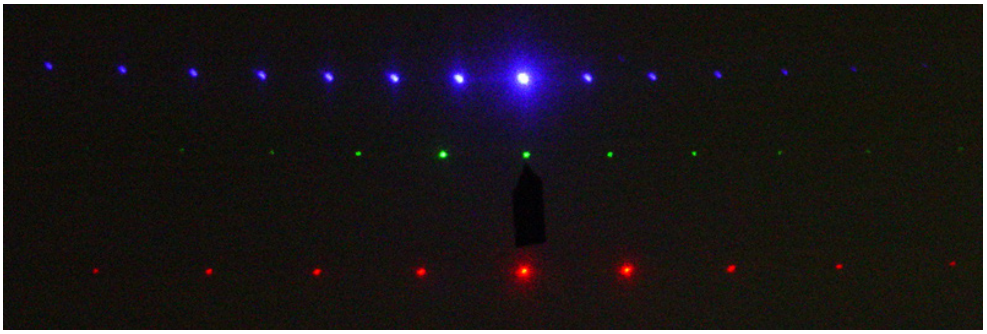
(d) Sam has the idea that if he holds the pipe while riding his bike really fast, he can recreate the same frequency in the pipe that the gust of wind had produced. Holding the pipe, Sam rides away from Miracle at a speed of 12.2 m s^{-1}. Sam hears the pipe resonate at a frequency of 1138 Hz, but Miracle measures a different frequency.

Calculate the frequency that Miracle would measure, and explain why the two frequencies are not the same.

QUESTION THREE: USING LASERS

Lasers are used extensively in scientific research as they are point sources of monochromatic coherent light. In a lab, interference patterns can be demonstrated by shining a laser through a diffraction grating and observing the pattern on a screen.





The picture above shows three different colours (from top to bottom: violet, green, and red) of laser light shone through the same diffraction grating.

ASSESSOR'S USE ONLY

(a) Describe, using physics principles, why the violet maxima (bright spots) are closer together than the red maxima.

(b) The diffraction grating has 400 slits / mm, and the angle between the centre and second order maxima is 20.7° for the violet laser.

(i) Show that the slit separation of the diffraction grating is 2.5×10^{-6} m.

(ii) Calculate the wavelength of the laser light.

Question Three continues on the following page.

ASSESSOR'S USE ONLY

(c) Explain the role of diffraction and interference in producing interference patterns seen when light passes through a diffraction grating. (Assume the light is monochromatic.)

(d) The wavelength of the light from the green laser is 5.32×10^{-7} m.

Describe and explain what would be seen at a point 28.6° from the centre of the green interference pattern.

A calculation should accompany your discussion.

SPARE DIAGRAMS

ASSESSOR'S USE ONLY

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

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

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

QUESTION NUMBER

ASSESSOR'S USE ONLY

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

QUESTION NUMBER

ASSESSOR'S USE ONLY

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

QUESTION NUMBER

ASSESSOR'S USE ONLY

91523