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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 2025

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 2–15 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 DOPPLER EFFECT

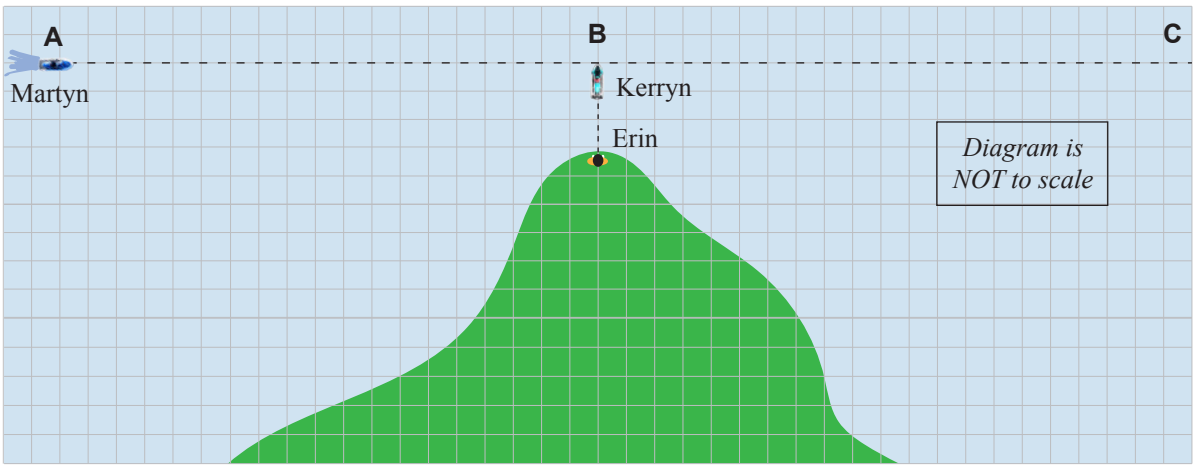
https://www.sea-doo.gr/blog/types-of-jet-skis/

Martin and Kerryn are riding their jet skis on a lake. Martyn's jet ski is fitted with an air horn that emits a frequency of 1043 Hz. At one point, Kerryn stops and Martyn travels directly towards her at a speed of 27.3 m s^{-1}. The speed of sound in air is 343 m s^{-1}.

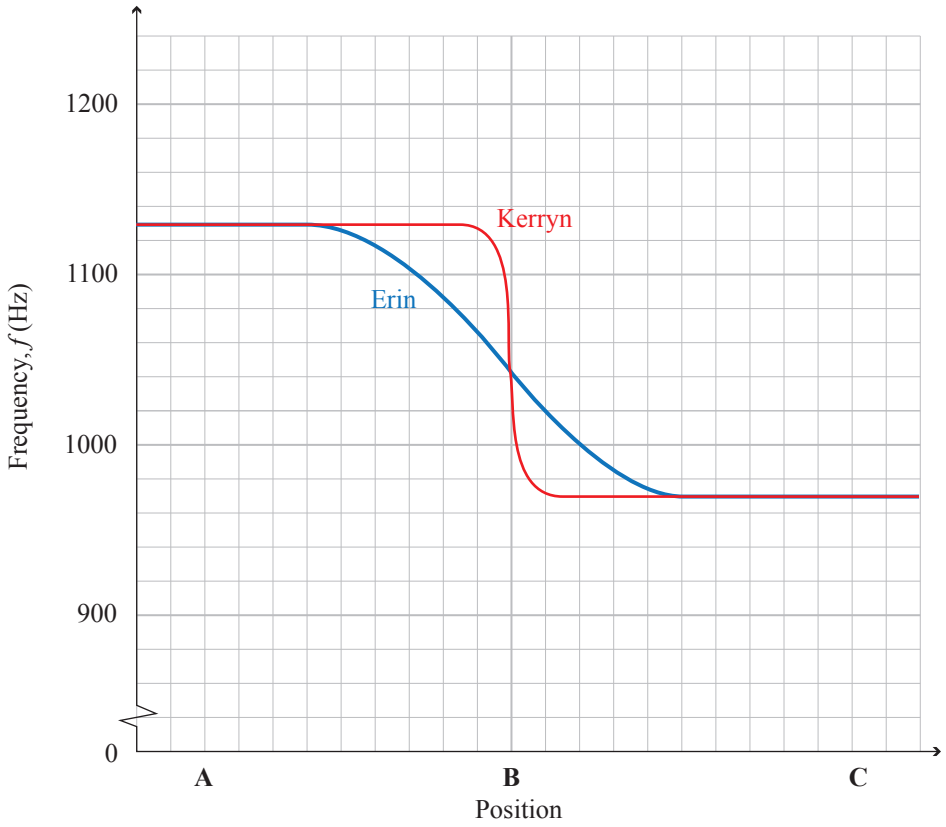
(a) Calculate the frequency of the sound that Kerryn hears.

(b) Explain why Kerryn hears a different frequency than that emitted by the jet ski's air horn.

(c) Kerryn is floating very close to the path of Martyn's jet ski, while her friend Erin is watching from a bank on the edge of the lake.



The graph shows the frequency of the sound heard by Kerryn and Erin as the jet ski travels from A to C.

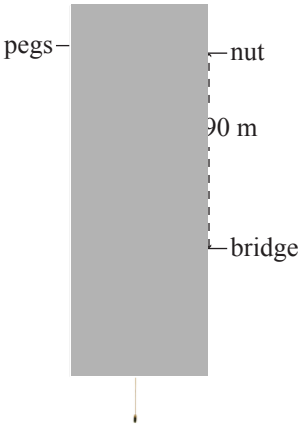


Explain why the frequency that Kerryn hears is the same or different to that which Erin hears.

(d) An underwater microphone has been submerged in the lake to monitor noise pollution from jet ski engines. Martyn's jet ski engine makes a sound at 574.0 Hz. As the jet ski travels away from the underwater microphone at 27.3 m s^{-1}, the microphone measures a frequency of 563.6 Hz coming from the jet ski engine.

Calculate the velocity of sound in water.

QUESTION TWO: STANDING WAVES



Source: https://en.wikipedia.org/wiki/Cello#/media/File:Cello_front_side.png

The cello is a stringed instrument belonging to the violin family.

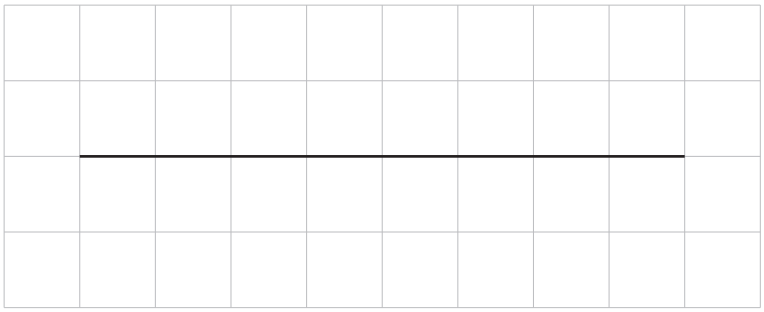
The strings are supported at each end by a piece of wood called the bridge and the nut respectively.

The length of the strings between the supported ends is 0.690 m.

When the cello is played, the strings can vibrate in different harmonics.

(a) Draw a diagram of the 4th harmonic.

Label the nodes and antinodes.



If you need to redraw your response, use the diagram on page 11.

(b) Sometimes if the cello has been in storage, the tension in the strings will decrease, and the instrument will be out of tune. The strings will therefore play a frequency that is other than the desired frequency.

Use the equation below to explain how this could have caused the frequency to be higher or lower than the desired frequency.

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

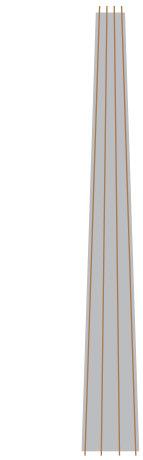
No calculations are required.

(c) When a 0.690 m string is played, the first harmonic has a frequency of 147 Hz. A finger is then pressed onto the string, changing the length of the string to play a first harmonic with a frequency of 207 Hz.

Calculate the new length of the string when the second note of 207 Hz is played.

Assume that the tension in the string remains constant.

(d) Two strings that are next to each other can be played at the same time. When string 2 is played (without a finger being pressed on it), it produces a note with a frequency of 98.0 Hz. Strings 1 and 2 are played at the same time that a finger is pressed onto string 1, and the length of string 1 is gradually reduced until a beat is heard.



(i) Explain why beats form.

(ii) Explain what will be heard as the length of the string continues to be gradually reduced.

QUESTION THREE: INTERFERENCE PATTERNS

A laser shines green light onto a double slit, which has a slit separation of 1.25×10^{-4} m. Each slit then acts as a light source that is in phase, producing an interference pattern on a screen with fringes that are close together.

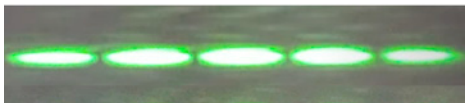
Diagram is NOT to scale

Source: https://courses.lumenlearning.com/suny-physics/chapter/27-3-youngs-double-slit-experiment/

When the screen is 3.40 m from the slits, the distance from the central maxima to the 3rd order maxima is 4.20×10^{-2} m.

(a) Show that the laser has a wavelength of 515 nm.

(b) Explain why the intensity of the light on the screen varies, as shown.

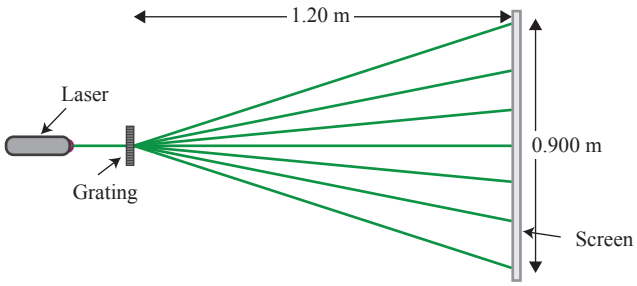
2 slits 

(c) The double slit is replaced with a diffraction grating which has more closely-spaced slits.

Describe and explain the changes to the interference pattern observed on the screen.

Question Three continues on the following page.

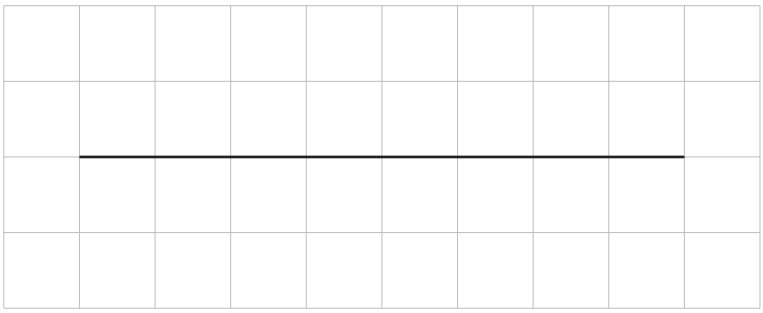
(d) In another experiment, a green laser, of wavelength 515 nm, is shone through a different diffraction grating and 7 maxima are seen on the screen. The screen is 0.900 m wide and is 1.20 m from the diffraction grating.



Calculate the possible range of values for the slit separation of the diffraction grating.

SPARE DIAGRAM

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



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