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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Physics 2026

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.

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QUESTION ONE: STANDING WAVES

Bethany has a flute that can be modelled as a 0.600 m long pipe open at both ends.



Source: www.musicworks.co.nz/yamaha-yfl222-flute-offset-silver-yfl222?srsltid=AfmBOopEZqmqQoyXOa7crSw2M3NN4OVEqfGsLDUrRgCMIaZROMkpuEcX

When all holes are closed, except the open end and the mouthpiece, and air is blown across the mouthpiece, a series of harmonics is heard.

(a) Sketch the fundamental (first harmonic) standing wave that forms in the flute, labelling all displacement nodes and antinodes.

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

(b) Bethany produces the fundamental harmonic of frequency 285 Hz.

Show that the speed of the wave in the air inside the flute is 342 m s^{-1}.

(c) Harry has a flute of length 0.605 m. When he and Bethany produce their fundamental (first harmonic) at the same time, beats are formed. The speed of sound in air is unchanged from part (b).

(i) Calculate the beat frequency heard.

(ii) Explain how beats are formed.

(d) Bethany uses tape to close the end of the flute, as shown. This models a closed-end pipe, where all the holes are closed, with the mouthpiece as an open end.



(i) Sketch the fundamental (first harmonic) standing wave formed in the flute with a closed end.

Label any nodes and antinodes.

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

(ii) Explain how closing one end of the flute results in only odd-numbered harmonics being formed.

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The assessment continues on the following page.

QUESTION TWO: DOPPLER EFFECT



Adapted from: www.freepik.com/premium-vector/drawing-girl-riding-bicycle-profile-athlete_40829883.htm
www.istockphoto.com/vector/set-of-business-people-in-various-poses-gm2164895554-585140530

Bethany rides her bicycle at 12.0 m s^{-1} directly away from her friend Sam. She has a speaker attached to her bicycle which produces a sound of frequency 522 Hz.

Use the speed of sound in air = 3.40×10^2 m s^{-1}.

(a) Calculate the frequency heard by Sam.

(b) Explain why the frequency heard by Sam is lower than that produced by the speaker.

(c) Bethany then slows down and comes to a stop.

Explain what will happen to the frequency and wavelength of the sound Sam hears as Bethany slows, and then comes to a stop.

(d) Bethany resumes cycling at 7.00 m s^{-1} and with the sound of 522 Hz coming from her speaker. Sam can hear Bethany's speakers at a frequency of 533 Hz.

(i) Identify whether Bethany is approaching or moving away from Sam.

Justify your answer.

(ii) Determine the speed of sound in air at this time.

State any assumptions you have made.

QUESTION THREE: INTERFERENCE PATTERNS

A red laser with a wavelength of 6.40×10^{-7} m is shone through a double slit, with a slit separation of 1.20×10^{-4} m, onto a screen 2.50 m away from the double slit. This is shown below.

Diagram is NOT to scale



(a) Calculate the distance between the $n = 0$ and $n = 2$ maxima.

A green laser (frequency of 5.30×10^{14} Hz) replaces the red laser (frequency of 4.69×10^{14} Hz), and is shone through the double slit.

(b) Describe and explain how the pattern of maxima changes.

(c) The double slit is replaced with a diffraction grating of 100 lines per mm.

The green laser is projected through the grating onto a 1.50 m wide screen, 2.50 m away from the diffraction grating.

Calculate the total number of bright fringes that will appear on this screen.

(d) Compare and contrast the interference patterns produced by the double slit and the diffraction grating using the green laser.

SPARE DIAGRAMS

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.

If you need to redraw your response to Question One (d)(i), 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

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

QUESTION NUMBER