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NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Physics 2023

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 2–8 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (DO NOT WRITE IN THIS AREA DO NOT WRITE). 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: SAM'S VIOLIN

Assume that the speed of sound in air is 342 m s^{-1}.

A violin is a stringed instrument onto which the strings are fixed at both ends. The fixed points are 0.331 m apart. Sam plays the violin, making the strings vibrate by pulling and pushing a bow across the strings.

One string (called the "G") is arranged to play a fundamental frequency of 196 Hz.

https://stock.adobe.com/nz/search?k=lady+playing+violin

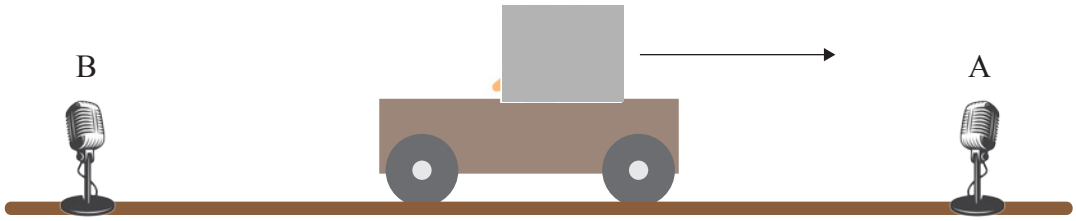
(a) Calculate the speed of the wave that travels along the string.

(b) Analysis of the sound produced by the vibrating string shows that it also vibrates at 392 Hz and 588 Hz.

State the harmonic that causes the vibration at 588 Hz.

Your answer should include a sketch that shows the location of the nodes and antinodes.

(c) Sam plays her violin (with a fundamental frequency of 196 Hz) as she sits on a moving trailer. The trailer is moving at 5.30 m s^{-1} directly towards microphone A.



Sources: https://www.freepik.com/premium-vector/young-woman-playing-violin-cartoon-character-violinist-playing-classical-music-vector-illustration-isolated-white-background_21596785.htm
www.freepik.com/free-photos-vectors/microphone-clip-art

Calculate the frequency recorded by microphone A.

(d) Microphone B is directly behind the moving trailer, whereas microphone A is directly in front of the moving trailer.

Explain how the motion of the trailer with Sam sitting on it playing the violin affects:

- the frequency of the string
- the speed of the sound in the air
- the wavelength of the sound in the air in front of and behind the violin
- the frequencies detected by microphones A and B.

QUESTION TWO: VIOLIN TUNING

On a hot day, the violin easily goes out of tune – Sam has to adjust the tension in the string to keep the "G" string so that it still vibrates at 196 Hz.

(a) Describe what happens to the fundamental frequency of the string when the string gets longer (and nothing else changes).

(b) Sam uses a tuning fork that will always vibrate at 196 Hz. She plays the string while sounding the tuning fork and hears a beat.

- Describe what is meant by a beat.
- Explain why beats are heard.

(c) Sam hears a beat of 2.1 Hz.

(i) Determine the possible frequencies at which the string is vibrating.

She increases the speed of the wave along the string by increasing the tension in the string and the beat frequency increases.

(ii) Use this information to determine the frequency at which the string was vibrating before adjustment.

(iii) Explain what Sam must do to get the string to vibrate at 196 Hz.

(iv) State how she will know when the string is vibrating at 196 Hz.

(d) When Sam plays a frequency of 564 Hz near a wine glass, the wine glass rattles on the shelf.

Give an in-depth explanation of this phenomenon by:

(i) describing the phenomenon

(ii) explaining how she might stop the wine glass from vibrating when she plays the violin.

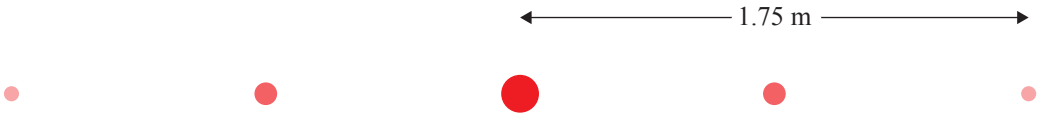
QUESTION THREE: DIFFRACTION GLASSES

At a fair, children are buying "Rainbow Glasses" made of diffraction gratings in a cardboard frame.

Steve shines a laser pointer through one of the diffraction gratings onto a wall. The laser pointer produces light with a wavelength of 643 nm (6.43×10^{-7} m). The light makes a pattern on the wall, with a bright red spot at the centre, and with slightly dimmer red spots either side.

The wall is 1.43 m from the grating. The distance from the central bright spot to the second slightly dimmer spot is 1.75 m.

Source: https://mindsetsonline.co.uk/shop/diffraction-glasses/



(a) Describe diffraction.

(b) Give an in-depth explanation why this pattern is observed by:

- explaining how diffraction and interference cause bright spots
- explaining why there are large sections where there is no light between the bright spots.

(c) Calculate the slit separation in the grating.

(d) When the children look at a spot of white light through the glasses, they see the white spot with spectra on either side (which they describe as “rainbows”).

Give an in-depth explanation of this phenomenon by:

- describing where the spectra will occur
- explaining the position of the colours in the spectra
- explaining why they are in these locations.

Include a labelled sketch to show the positions of different coloured light in the space below.

Space for labelled sketch:

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

QUESTION NUMBER