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Level 3 Physics 2022

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

Do not write in any cross-hatched area (▨). This area may be cut off when the booklet is marked.

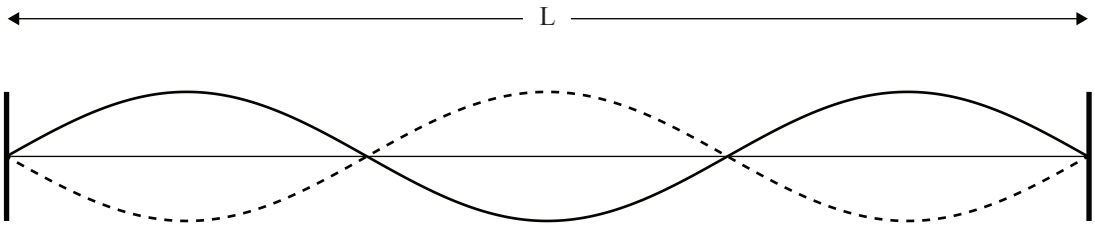
YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

QUESTION ONE: STANDING WAVES

Jane enjoys playing the guitar.

When Jane plucks the string, one of the resonant harmonics that is produced, is shown in the diagram below.

Source: www.dkfindout.com/us/music-art-and-literature/musical-instruments/guitar/



(a) State which harmonic or (overtone) is shown in the diagram above.

Label at least one node (N) and one antinode (A) on the diagram.

If you need to redraw your response, use the diagram on page 8.

(b) The length of the guitar string is 0.645 m. The frequency of the harmonic, indicated in the diagram above, on the guitar string is 995 Hz.

Calculate the speed of sound through the string.

(c) While Jane is playing the note of 995 Hz on her guitar, her friend Mele tunes her guitar by playing the same note as Jane with the same loudness at the same time. They hear beats of 5.00 Hz. Mele tightens her guitar string, so that sound travels faster in the string, until beats are no longer heard.

- State Mele's original frequency.
- Explain the effect tightening the string has on the frequency of the note that Mele was producing on her guitar.

(d) Jane also plays the flute, which can be modelled as an open pipe. Mele plays the clarinet, which can be modelled as a pipe which is closed at one end and open at the other end.

Explain why Mele cannot produce the second harmonic on the clarinet, whereas Jane is able to produce the second harmonic on her flute.

QUESTION TWO: INTERFERENCE

Vincent is studying interference patterns formed by diffraction gratings. He has a set of diffraction gratings with different slit spacings. Vincent shines a red laser through the gratings, and observes the pattern formed on a screen that is some distance away.

(a) Describe the effect on the pattern of fringes that are formed on the screen when the distance, d, between slits increases (the width of the slits remain the same).

(b) Vincent uses the diffraction grating to study blue light from his new laser. He uses a grating with 6.00×10^5 lines per metre. He sees a series of bright dots that are the maxima. He measures an angle of 54.0° between the third bright dot (third order maxima) and the central bright dot.

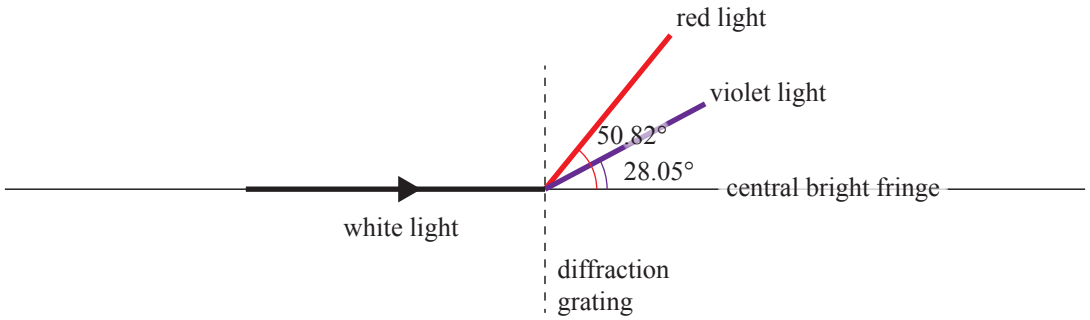
Calculate the frequency of light that he is observing.

(c) Vincent next shines white light through the same diffraction grating of 6.00×10^5 lines per metre. He notices that the central antinodal line is white, and each of the orders produces a complete spectrum.

Explain both observations using your knowledge of colours and wavelengths of light.

(d) While studying the effect of shining white light through the diffraction grating, Vincent carefully measures an angle of 28.05º for the violet light from the central bright fringe. He then measures an angle of 50.82º for the red light of the **same order**.

$\lambda_{red} - \lambda_{violet} = 2.54 \times 10^{-7}$ m



Calculate the wavelength of the red light.

Begin your answer by identifying what is common to both red light and violet light in the equation $n\lambda = d \sin\theta$.

QUESTION THREE: DOPPLER EFFECT

Speed of sound in air = 3.40×10^2 m s^{-1}

Two police cars have identical sirens of frequency 7.50×10^2 Hz. One of them is stationary while the other police car is approaching Emma, who is standing on the kerb.

(a) Compare the pitch of the note that Emma hears to the pitch of the note the driver of the car hears, as his car approaches her with its siren on.

(b) The stationary car, as well as the car approaching Emma, sound their sirens. The frequency heard by Emma differs from the true (actual) frequency by 8.50 Hz.

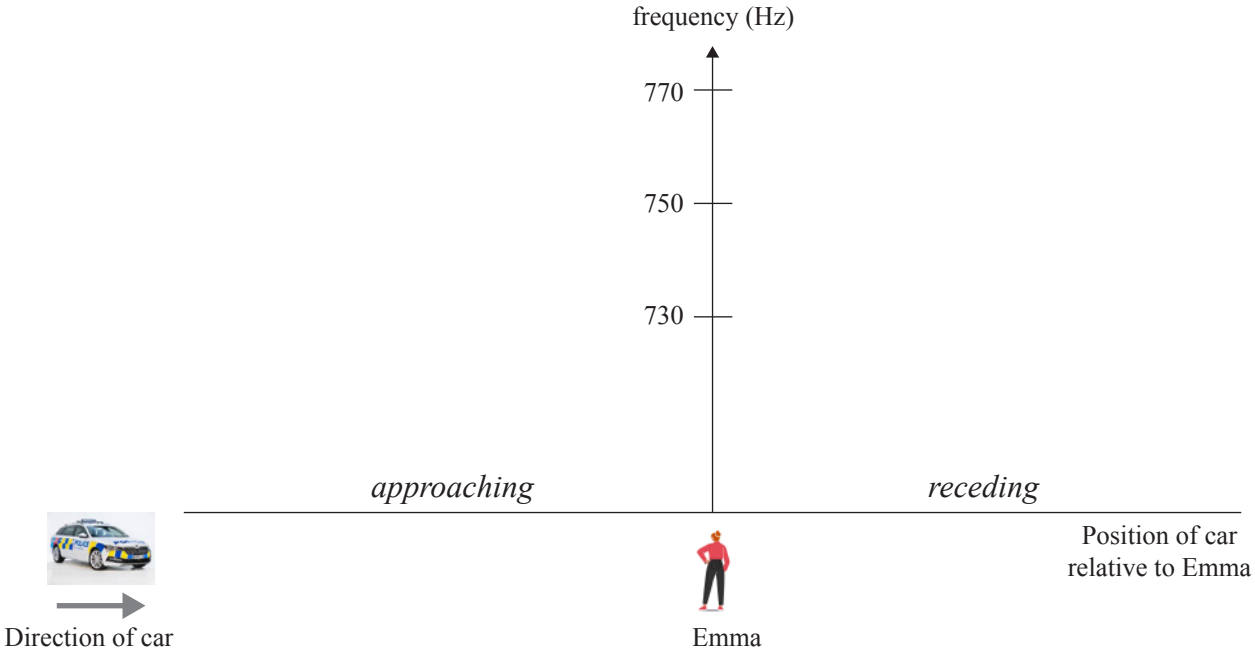
Show that the speed of the approaching police car is 3.81 m s^{-1}.

(c) Emma is standing very close to the side of the road as the police car approaches her, and then goes past her at a constant speed.

By calculating the apparent frequency of the sound that Emma hears when the police car goes away from her, sketch a graph of frequency against position using the axes drawn opposite above to show how the frequency of the sound that Emma hears changes as:

- the police car approaches her from a distance
- the police car recedes from her into the distance.

Graph of frequency against position



Source: www.skoda-storyboard.com/en/press-releases/first-skoda-superb-combi-for-new-zealand-police-force/
www.vectorstock.com/royalty-free-vector/ginger-hair-woman-back-view-female-character-vector-39949834

If you need to redraw your response, use the diagram on page 8.

(d) Explain the reason for the shape of the graph you have drawn.

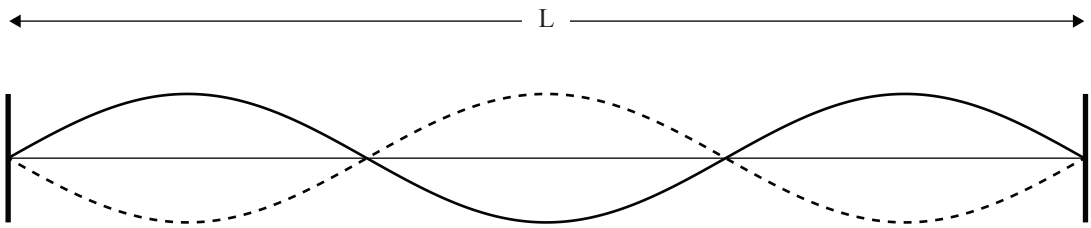
In your answer comment on the shape of the graph as the car:

- approaches Emma
- goes past Emma.

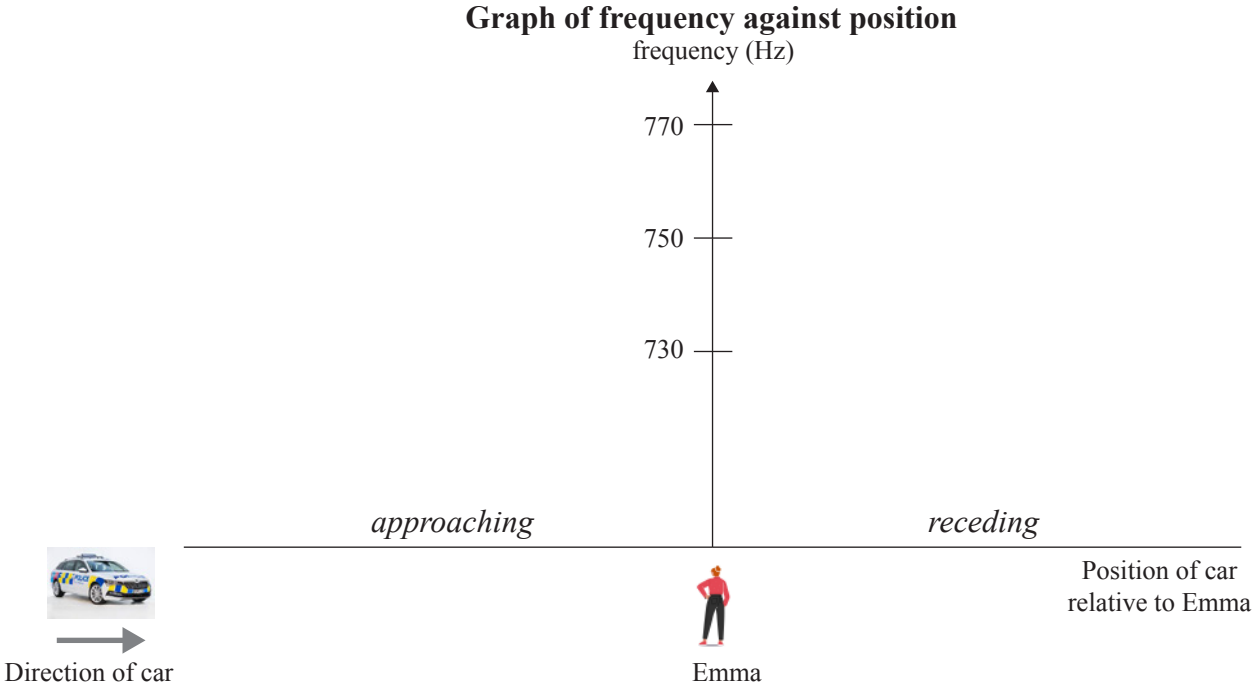
Include a comment on the gradient of the graph as the car, with its siren sounding, approaches and goes past Emma.

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 Three (c), use the diagram below. Make sure it is clear which answer you want marked.



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Write the question number(s) if applicable.

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