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SUPERVISOR'S USE ONLY

Level 3 Physics, 2016

91523 Demonstrate understanding of wave systems

2.00 p.m. Tuesday 15 November 2016
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 2–8 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.

Merit

TOTAL 19

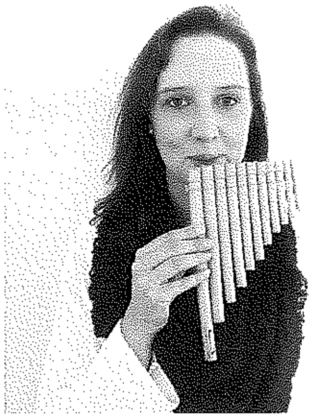
ASSESSOR'S USE ONLY

QUESTION ONE: PAN FLUTES

ASSESSOR'S USE ONLY

Assume the speed of sound in air is 343 m s^{-1}.

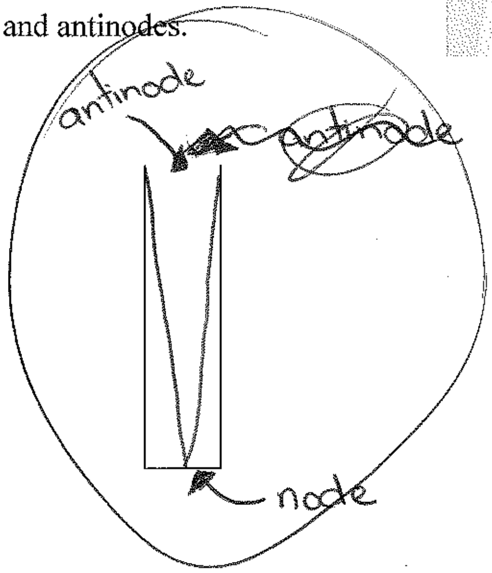
A pan flute is a musical instrument made of a set of pipes that are closed at one end. Maria produces different frequency notes by blowing air across the top of different pipes.



Maria is producing the fundamental frequency (first harmonic) in one pipe.

(a) On the diagram below draw the standing wave Maria is producing in the pipe.

Label the displacement nodes and antinodes.



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(b) Maria blows across one pipe and a fundamental frequency of 350 Hz is produced. A second pipe produces a fundamental frequency of 395 Hz.

Explain which pipe is longer.

$v = f\lambda \quad \lambda = \frac{v}{f}$

$\lambda_1 = 343 \div 350 \quad \lambda_1 = 0.980\text{m}$

$\lambda_2 = 343 \div 395 \quad \lambda_2 = 0.868\text{m}$

In a closed pipe $\lambda = 4L$ so

$0.980 = 4L \quad L_1 = 0.245\text{m} \quad 0.868 \div 4 =$ $L_2 = 0.217\text{m}$

So the first pipe is longer than the second.

u

Maria blows air across one of her pipes and it produces a third harmonic with a frequency of 762 Hz. At the same time, her friend Sophie blows air across a similar pipe and also produces a third harmonic. They both hear a sound of 764 Hz, which is the average of the two frequencies. The sound varies in loudness, at a frequency of 4.00 Hz.

ASSESSOR'S USE ONLY

(c) State the name of this phenomenon, and explain how it causes Maria to hear a variation in loudness.

This is referred to as a beat where there are two sound waves that have slightly different frequencies which in this case is 762 Hz and 764 Hz. The beat is created as the two waves go in phase and drift back out of phase with each other. When they are in phase with each other they become louder because constructive interference occurs, and the ~~quiet~~ quieter when they are out of phase. The beat / difference in frequencies is 4.00 Hz

i

(d) Calculate the length of Sophie's pipe.

$f = \frac{3v}{4L}$ $\quad 4L = \frac{3v}{f}$

$4L = (3 \times 343) \div 766$

$4L = 1.34$

$L = 0.336\text{m}$ (3sf)

C

E7

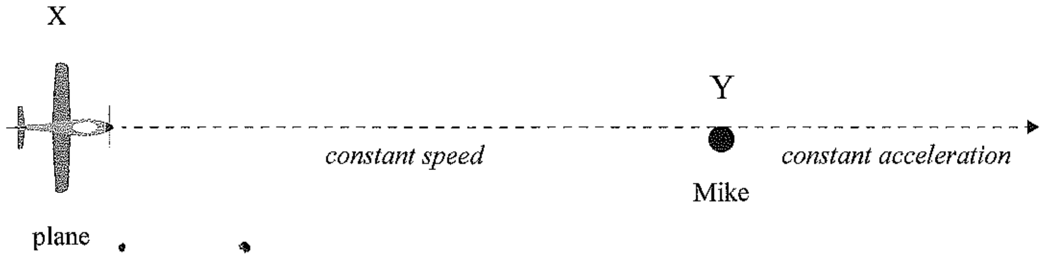
QUESTION TWO: A RADIO CONTROLLED PLANE

ASSESSOR'S USE ONLY

Mike is flying his radio controlled plane. The plane flies towards him at constant speed, and then away from him with constant acceleration, as shown in the diagram below.

The plane is producing a constant frequency of 185 Hz.

Assume the speed of sound in air is 343 m s^{-1}.



(a) Describe and explain the frequency of the sound Mike hears when the plane is at position X.

When the plane is at position X, the ~~fa~~ sound waves produced will bunch up infront as the plane catches up to them, resulting in a shorter wavelength. Since the plane is at a constant speed velocity will remain the same which means the frequency of the sound heard by Mike will be higher from the equation $v=f\lambda$.

i

(b) Describe the frequency of the sound Mike hears when the plane is at position Y.

Mike will hear the exact frequency of 185 Hz because the plane is right by him so the planes movement does not affect the frequency heard by Mike at position Y.

u

(c) Describe and explain the frequency of the sound Mike hears as the plane gradually accelerates away from him.

As the plane accelerates away from Mike the frequency heard by him will decrease. This supported by dopplers formula $f' = f \frac{V_W}{V_W \mp V_S}$. Since the plane is moving ~~to~~ away from Mike we add V_S which results in a smaller frequency. As the plane accelerates the value of V_S will increase as velocity increases when the plane accelerates. This will result in the frequency gradually decreasing as the plane accelerates away from Mike.

Earthquake
2:35pm
5.8

U

(d) Calculate the speed of the plane when the sound waves being produced behind it have a wavelength of 2.00 m.

$v = f\lambda \quad f' = \frac{v}{\lambda} \quad f' = 343 \div 2 \quad f' = 171.5\text{ Hz}$

$f' = f \frac{V_W}{V_W + V_S}$

$171.5 = 185 \left(\frac{343}{343 + V_S}\right)$

$0.927 = \left(\frac{343}{343 + V_S}\right)$

$317.97 + 0.927 V_S = 343$

$\cancel{0.927 V_S = 1.079}$ $\quad 0.927 V_S = 25.03$

$\cancel{V_S = 1.16\text{ ms}^{-1}}$ $\quad V_S = \underline{27.0\text{ ms}^{-1}}$ (3sf)

C

E7

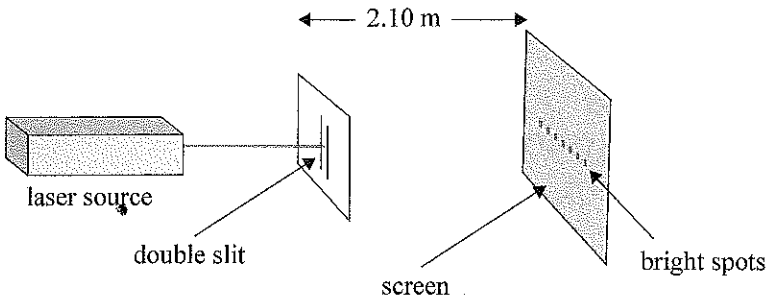
QUESTION THREE: DIFFRACTION GRATINGS

ASSESSOR'S USE ONLY

Moana is doing an experiment in the laboratory. She shines a laser beam at a double slit and observes an interference pattern on a screen. The diagram below shows the experiment. Moana measures the distance between adjacent bright spots (maxima) and finds they are 0.0100 m apart.

The slits are 1.28×10^{-4} m apart.

The screen is 2.10 m from the slits.



(a) Show that the wavelength of the laser light is 6.10×10^{-7} m.

$n\lambda = dx \div L$

$\lambda = (1.28 \times 10^{-4} \times 0.0100) \div 2.10$

$\lambda = 6.10 \times 10^{-7}$ m

Moana replaces the double slit with a diffraction grating in the same position. The diffraction grating has 500 lines per mm.

(b) Calculate the angle between the central antinodal line and the first antinodal line.

$d \sin\theta = n\lambda$

$\sin\theta = 6.10 \times 10^{-7} \div 2 \times 10^{-6}$

$\sin\theta = 0.305$ $\theta = \sin^{-1}(0.305)$

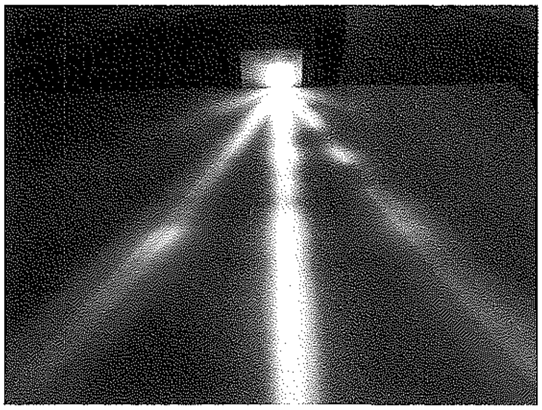
$\theta = 17.8°$ (3sf)

(c) Explain what would happen to the distance between the bright spots on the screen if the laser source is changed to one with a shorter wavelength.

If the laser source was changed to one with a shorter wavelength the distance between the bright spots on the screen would decrease. This is because of the equation $n\lambda = dx \div L$, if λ decreases then x must decrease if all other factors remain constant. Also a smaller wavelength would be diffracted by less if the slits remain the same causing the distance between the dots to decrease.

(d) Moana then shines white light through a diffraction grating. The pattern she sees is shown below.

ASSESSOR'S USE ONLY



Explain the pattern Moana observes.

Your explanation should include:

- why the centre of the pattern is white
- why there is a coloured spectrum on each side
- why ~~there are dark regions between the white and coloured regions.~~

The centre of the pattern is white because this is where most of the light goes through as ~~it~~ this path does not require any interference of light waves. White is like pure light. The coloured spectrum on either side is created from constructive and destructive inteference of the light waves on each other. More interference occurs near the centre so the colours get less clear and start to dim as it moves away from the middle. The dark regions is where no light waves pass through at all due ~~to~~ interference of waves ~~bad~~ reflecting light through the paths of colour. ~~When the colours a~~ Where the coloured spectrum is clearer and more ~~definitive~~ definite more constructive interference occurs whereas where the colours are less clear more destructive interference occurs. The white light has no interference so the colour is completely clear (white).

M5

Annotated Exemplar 91523 2016

Merit exemplar 2016

Subject:	Physics	**Standard:**	91523	**Total score:**	19

Q	Grade score	Annotation
1	E7	The explanation in 1b doesn't have a written statement that the wavelength of the fundamental standing wave in the pipe is inversely proportional to the frequency. The explanation in 1c explains beats as a variation in loudness **over time** linked to the **phase** difference and **type of interference** needed to make the sound louder (and softer)
2	E7	In part c the explanation clearly describes the frequency heard by Mike dropping over time. The dropping frequency is not explained by the wavelengths of the waves travelling towards Mike getting longer and longer, but simply by a formula.
3	M5	The explanation for 3d is incorrect for all three bullet points, however the first three parts have been answered fully and accurately.