3

SUPERVISOR'S USE ONLY

91523

915230

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

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.

Achievement

TOTAL 07

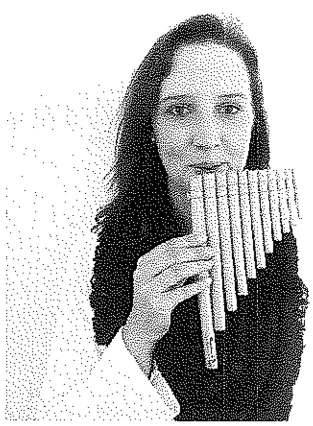
ASSESSOR'S USE ONLY

QUESTION ONE: PAN FLUTES

ASSESSOR'S USE ONLY

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

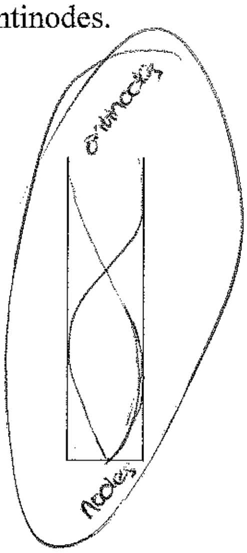
A pan flute is a musical instrument made of a set of pipes that are closed at one end. Maria produces different frequency notes by blowing air across the top of different pipes.



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.



$v = f\lambda$

(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.

The pipe that has the frequency of 350Hz is longer. ~~This is due to the fact that it's frequency is 350Hz which is 3/4 longer wavelength~~ This is because the 3/4 wavelength produces a higher frequency when the wave being produced is in a longer medium. The wavelength produces a higher frequency in areas that the wavelength being produced is longe

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.

The phenomenon that occurs is beats. Beats occur when two instruments produce the similar frequency however differ in different frequencies. Hence why we hear ~~[illegible]~~ loud and soft noise. Maria hears a variation in loudness due to the instruments harmonics and overtones are in different orders. ~~They may resonate~~ Such as at frequency of 4Hz it is loud however in different frequencies, their overtones may be different.

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

~~f = 764Hz L=? n=~~ f = 764Hz L = ? ~~[illegible]~~ N:

N∅

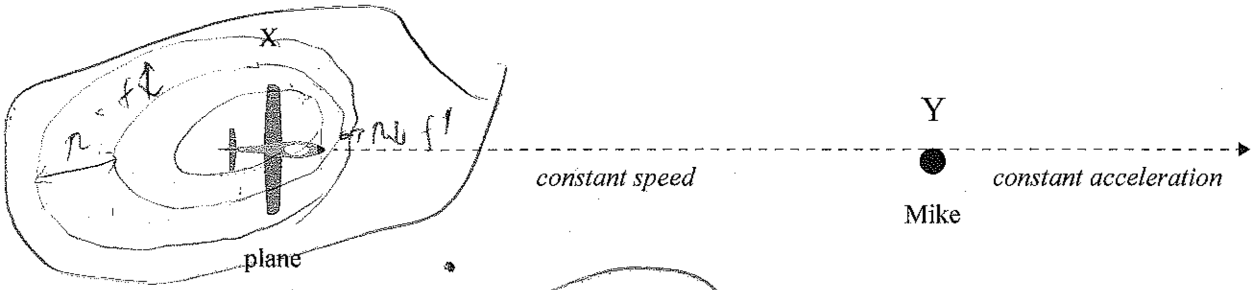
QUESTION TWO: A RADIO CONTROLLED PLANE

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}.



$v = f\lambda$

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

At position X, Mike hears the planes frequency however it is ~~at~~ only very quietly. The closer the plane is to Mike the louder he hears the plane. At position X, the wavelength being produced is ~~longer~~ shorter therefore it's frequency ~~higher~~ is ~~lower~~ higher, still maintaining that constant speed.

u

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

At position Y, Mike hears the plane's true frequency. It's equal frequency relative to it's speed and position. He hears the frequency of 185Hz

u

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

ASSESSOR'S USE ONLY

As the plane gradually accelerates from him he begins to hear the plane's frequency for a longer amount of time slowly dying off. This is due to the fact that it's wavelength (that are behind) are much longer as it accelerates, creating it's frequency to become lower. The frequency he hears ~~are~~ are the wavelengths that are further away from the plane. Hears a longer wavelength therefore a smaller frequency.

$v = \lambda f$

u

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

~~$v = ?$ $\lambda = 2m$ $f = 185Hz$~~

~~$v = \lambda \times f$~~

~~$= 2 \times 185$~~

~~$= 370ms^{-1}$~~

~~$f' = f \frac{v_w}{v_w \pm v_s}$~~

~~$185 = 185 \frac{v_w}{v_w \pm 343}$~~

$V = \lambda \times f$

$= 2 \times 185$

$= 370ms^{-1}$

A3

QUESTION THREE: DIFFRACTION GRATINGS

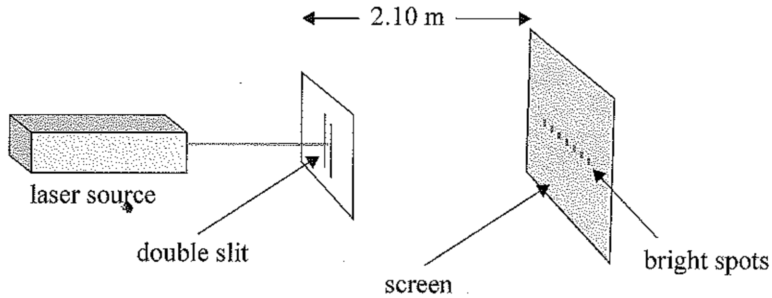
ASSESSOR'S USE ONLY

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.

distance between the antinodal

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.

$$n\lambda = \frac{dx}{L} = \frac{1.28 \times 10^{-4} \times 0.0100}{2.10}$$

$$= 6.09 \times 10^{-7} \text{ m}$$

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

y

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.

$$d \sin\theta = n\lambda$$

$$5 \times 10^{-3} \sin\theta = 6.10 \times 10^{-7}$$

$$\sin\theta = \frac{6.10 \times 10^{-7}}{5 \times 10^{-3}}$$

$$\theta = \sin^{-1}\left(\frac{6.10 \times 10^{-7}}{5 \times 10^{-3}}\right)$$

$$\theta = 6.99 \times 10^{-3}\,°$$

u

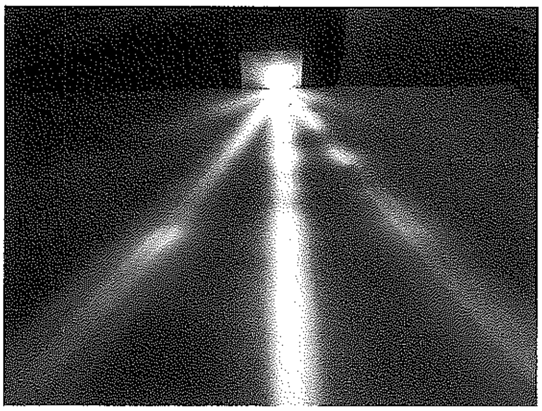
(c) Explain what would happen to the distance between the bright spots on the screen if the laser source is changed to one with a shorter wavelength.

If the laser is changed to one with a shorter wavelength, the distance between the bright spots would decrease ($n\lambda = \frac{dx}{L}$). ~~This~~ By keeping the same distance away from the screen, however shortening wavelength would lead to distances between maxima to become shorter. The antinodal lines would be closer to each other. Close angle. Maxima distances between next maxima is shorter.

i

(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 pattern is white due to the fact that it is an antinodal line, the starting points before the 1st antinodal lines on either side of it. There are coloured spectrum on either side of it due to the fact that the centre antinodal line is diffracting to create wavelengths of all sorts that meet, constructing, creating the colourful spectrum. The dark regions between the white and coloured regions are the nodal lines, lines which are deconstructive lines. Their wavelengths do not diffract to construct waves, therefore create areas of ~~deconstructive~~ dark regions. Regions of wavelength that are not strong, unlike areas of antinodal lines.

4

A4

Low achieved exemplar 2016

Subject:	Physics	Standard:	91523	Total score:	07

Q	Grade score	Annotation
1	N0	The diagram for 1a shows the wrong harmonic. The explanation for 1b is contradictory and does not backup the answer given, which may just be a guess. In part 1c the candidate has repeated parts of the question but has not explained what causes beats to be heard
2	A3	In 2a the description of changes to volume are considered neutral. There is no reason given as to why the wavelengths Mike receives are shorter. The candidate has described the frequency becoming lower in part c but not clearly linked this to an increasing wavelength over time.
3	A4	In part 3b the candidate has made just one mistake by calculating d as 5mm, but then substituting and solving correctly. In part 3d the only credit has been given for attributing the dark regions to destructive interference.

3

SUPERVISOR'S USE ONLY

91523

915230

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

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.

Achievement

TOTAL 12

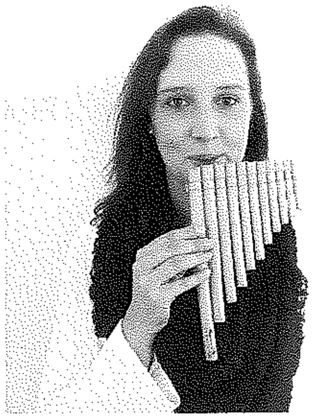
ASSESSOR'S USE ONLY

QUESTION ONE: PAN FLUTES

ASSESSOR'S USE ONLY

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

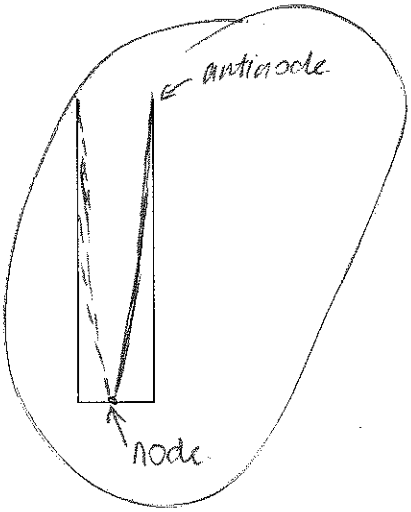
A pan flute is a musical instrument made of a set of pipes that are closed at one end. Maria produces different frequency notes by blowing air across the top of different pipes.



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.



(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.

~~$\lambda = \frac{f}{v} = \frac{350}{343} = 0.991m$ (3sf) $\lambda = \frac{395}{343} = 1.15m$ (3sf)~~

The wave length of the 1st pipe is larger, so the pipe must be longer than the pipe that has the fundametal frequency of 395Hz

$\lambda = \frac{v}{f} = \frac{343}{350} = 0.98m$ (3sf) $\lambda = \frac{343}{395} = 0.87m$ (3sf)

ASSESSOR'S USE ONLY

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.

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

They are hearing beats. Beats are caused by a small difference in frequency (in this case 4.00 Hz). The ~~beat~~ difference in frequency of the two ~~pipes~~ waves causes constructive interference (loudness) and destructive inteference (quiter parts) and creates a beat at 4.00 Hz.

U

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

766 Hz $\lambda = \frac{v}{f}$ ~~$= \frac{766}{343} = 2.233$ m (3sf)~~ $\frac{343}{766}$

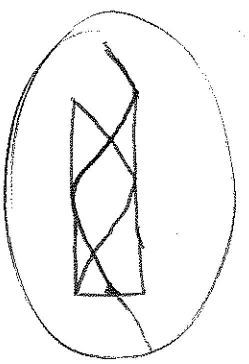
$\lambda = 0.44778$ m

$L = \frac{4\lambda}{3}$

~~$L = 2.977646208 = 2.98$ m (3sf)~~

$L = 0.597$ m (3sf)

U



A4

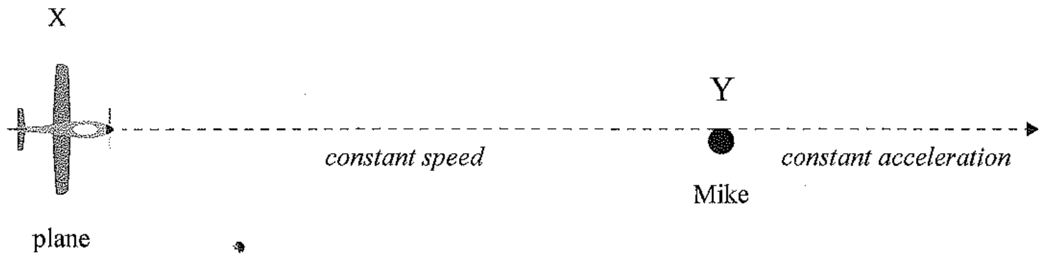
QUESTION TWO: A RADIO CONTROLLED PLANE

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.

Mike would hear a frequency higher than the actual frequency as the plane is moving at constant speed towards him and the sound waves ahead of ~~him~~ the plane are 'bunched up' as the plane is moving forward with the waves. causing wave length to become shorter and frequency to become higher.

1

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

Mike would hear the actual frequency of 185Hz.

U

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

ASSESSOR'S USE ONLY

As the plane gradually accelerates away from Mike, he will hear a lower frequency than the actual frequency, as the Plane is 'leaving the waves behind' so they are more spread out, meaning the wave length is longer, so the frequency is also lower and the speed of the wave stays constant.

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

$f' = f \dfrac{v_W}{v_W \pm v_S}$ $\quad f = \dfrac{\lambda}{v} = \dfrac{343}{2} = 171.5\ \text{Hz}$ ~~5.83×10^{-3} Hz~~

$V_S = \dfrac{V_W + (f \cdot V_W)}{f'}$ $\quad V_S = \dfrac{343 + (185 \cdot 343)}{171.5\ \text{Hz}}$ ~~5.83×10^{-3} Hz~~

~~$V_S = 10,400,000\ \text{ms}^{-1}$~~

$V_S = 372\ \text{ms}^{-1}$

U

A4

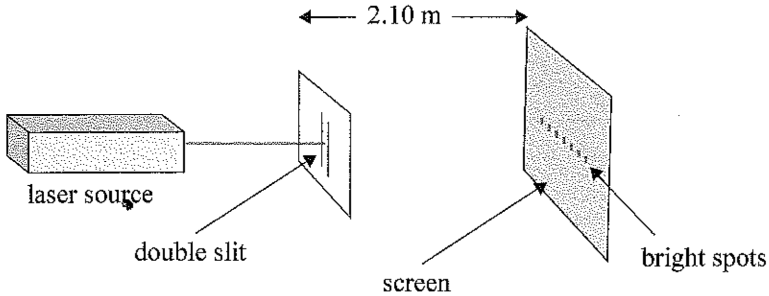
ASSESSOR'S USE ONLY

QUESTION THREE: DIFFRACTION GRATINGS

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.

$n\lambda = \frac{dx}{L}$ $n=1$ $d = 1.28 \times 10^{-4}$ m $x = 0.0100$ m $L = 2.1$

$\lambda = 6.095 \times 10^{-7}$ $= 6.10 \times 10^{-7}$ m.

U

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.

$d\sin\theta = n\lambda$ $\sin\theta = \frac{n\lambda}{d}$ $= \frac{1 \cdot (6.10 \times 10^{-7})}{2 \times 10^{-6} \text{ m}}$

$\sin\theta = 0.305$ $\theta = 17.8°$ (3 sf).

I

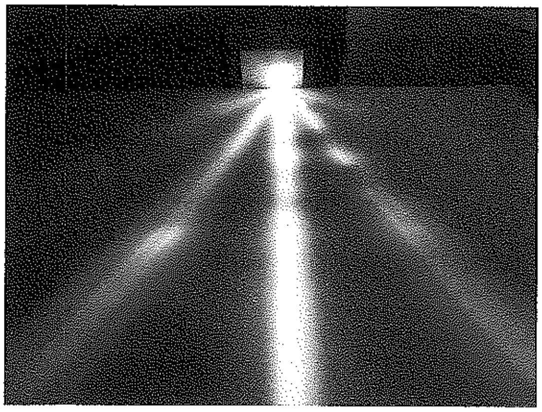
(c) Explain what would happen to the distance between the bright spots on the screen if the laser source is changed to one with a shorter wavelength.

A shorter wavelength means that the angle from the central antinodal line and the first antinodal line will be smaller as it does not diffract as much. This means that the distance between bright spots will be less and more bright spots will be present.

U

(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 as all wavelengths of visible light are combined to make white light, because white light is made up of all visible coloured lights. // There is a coloured spectrum on each side as the white light is made up of all the ~~[illegible]~~ visible ~~[illegible]~~ colours of light. They all have different wavelengths so are all diffracted different amounts, causing a coloured spectrum. Violet has the shortest wavelength, so is diffracted the least, and red has the longest wavelength, so is diffracted the most. The dark regions in between the white and coloured regions are nodal regions, where destructive interferance has caused the wavelengths to cancel out into areas of darkness. The waves coming from the diffraction grating are not in phase, causing the dark areas.

4

A4

High Achieved exemplar 2016 (127487118)

Subject:	Physics	Standard:	91523	Total score:	12

Q	Grade score	Annotation
1	A4	The 350Hz pipe is shown to have a longer wavelength but this is not shown to be caused by a longer pipe length through a calculation or a statement that the pipe length is proportional to the wavelength. The beats explanation is missing the fact that the waves must go from in-phase to opposite phase in order to change from constructive to destructive interference. The calculation of frequency and wavelength for Sophie's pipe are correct, but the following calculations are wrong.
2	A4	In 2a there is a good explanation of why the frequency of the sound heard by Mike is higher, using the idea that "bunching up" of waves in front of the plane makes the wavelength shorter. Constant wave speed is also a condition of the frequency and wavelength being inversely proportional but this was not required as evidence this time. In part c the explanation describes the frequency heard by Mike being lower rather that getting lower over time. The Doppler formula has been incorrectly rearranged in part d although the calculation of observed frequency is the correct first step.
3	A4	The answers to the calculations are complete and accurate. The reason is incorrect but the statement in part c that the antinodes will be closer together is correct. Only achieved has been awarded for part d as the explanation for the dark regions is correct but the candidate refers to "the waves" while neglecting to mention that all the wavelengths must be destructively interfering if no light is seen. The explanation for the coloured spectra seems to confuse diffraction with refraction, and disregards interference as the reason.