SUPERVISOR'S USE ONLY

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Draw a cross through the box (☒) if you have NOT written in this booklet

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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

# Level 2 Physics 2023

## 91170 Demonstrate understanding of waves

Credits: Four

| Achievement | Achievement with Merit | Achievement with Excellence |
|---|---|---|
| Demonstrate understanding of waves. | Demonstrate in-depth understanding of waves. | Demonstrate comprehensive understanding of waves. |

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 Sheet L2–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 2–16 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.**

Merit 18

## QUESTION ONE: THE COSTUME SHOP

Marco and Harvey head to the mall to buy props for the school show. Their first stop is the costume shop.

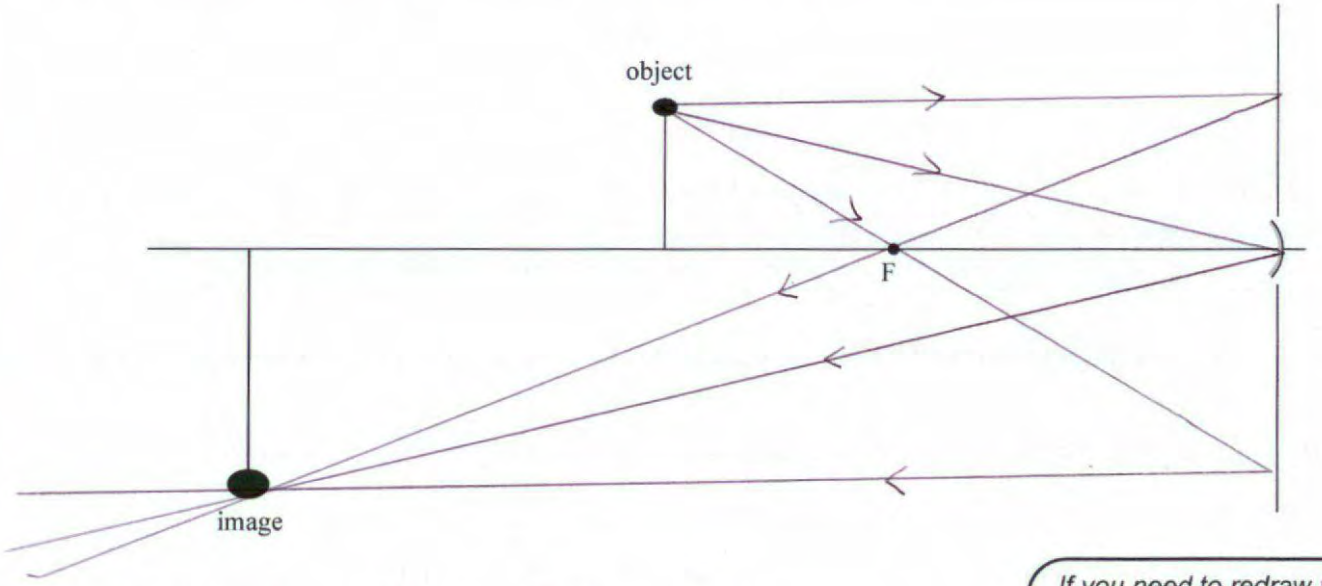
The students start looking at hats in a concave mirror of focal length 25 cm. The mirror image is initially real.

(a) Define the term real as it is used in this context.

It means that the image can be seen and it is not virtual.

Marco stands 40 cm in front of the mirror and the image is formed in the location shown below.

(b) Complete the diagram below to show how this image forms.




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

(c) Calculate the magnification of the image formed.

$f = 25\text{cm}$ $do = 40\text{cm}$ $di = ?$

$1/f = 1/do + 1/di$

$1/25 = 1/40 + 1/di$

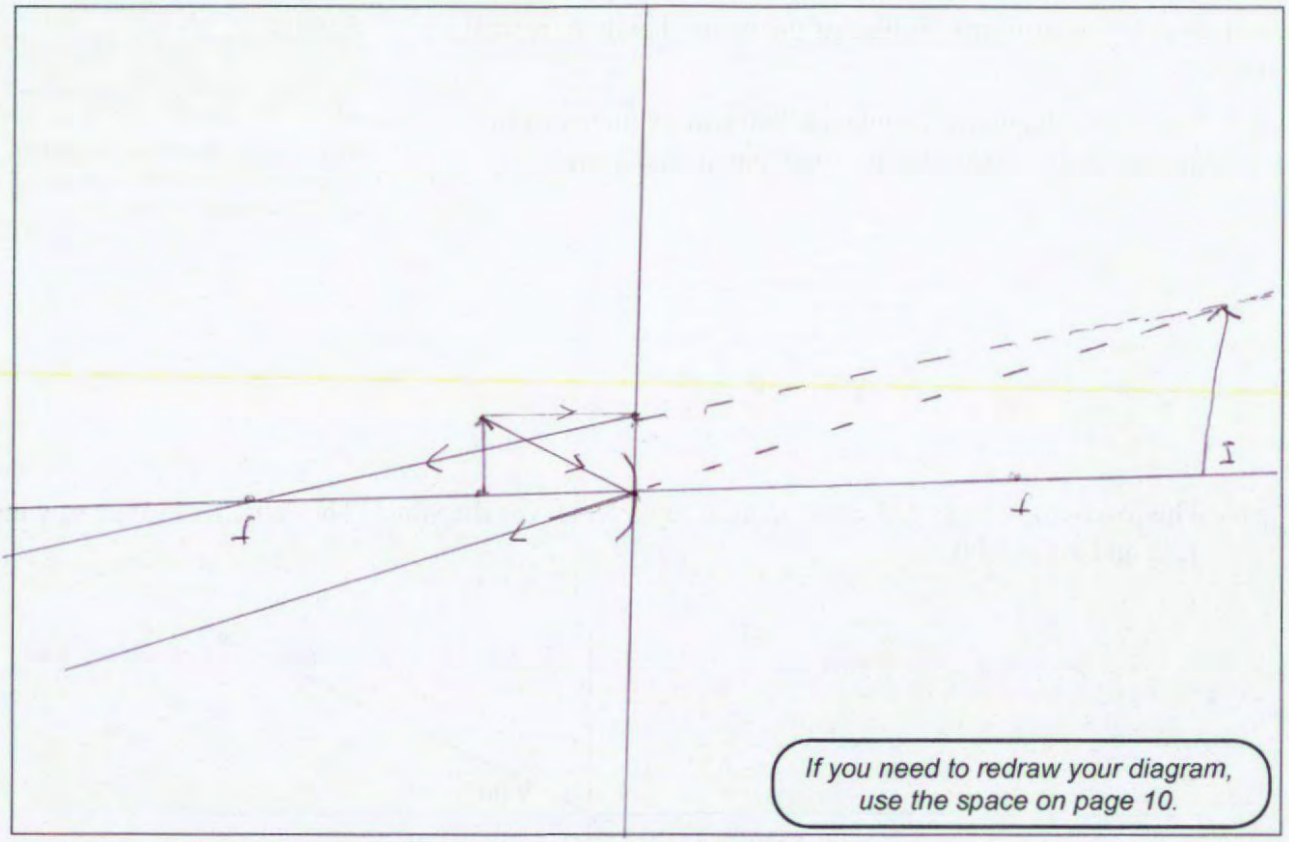
$di = \frac{1}{\frac{1}{25} - \frac{1}{40}}$

$di = 66.67$

$= 67\text{ cm}$ (2SF)

(d) Harvey now stands 10 cm in front of the concave mirror.

By using a ray diagram and calculating the image distance and magnification, describe and explain the nature of the new image formed.




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

$d_o = 10\,cm \quad f = 25\,cm$

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$\frac{1}{25} = \frac{1}{10} + \frac{1}{d_i}$

$d_i = \left(\frac{1}{25} - \frac{1}{10}\right)^{-1}$

$= -16.67\,cm$

$= -17\,cm\ (2SF)$

$m = d_i / d_o$

$= 16.67 / 10$

$= 1.67$

$= 1.70\ (2SF)$

The image is virtual, upright enlarged.

Appa

## QUESTION TWO: THE WISHING POND

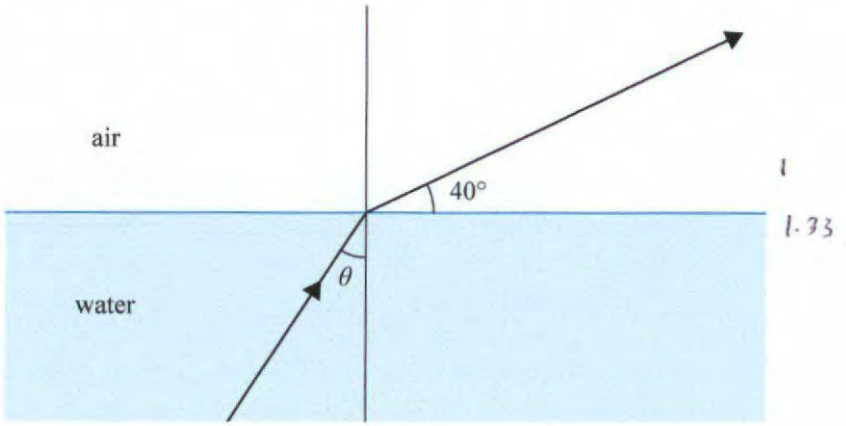
The students walk past a wishing pond for a local charity. People throw coins into the water, and these are collected at the end of the day. As the students sit on the side of the pond, they notice the coins appear closer to the surface of the water than they actually are.

https://www.istockphoto.com/photo/many-coins-thrown-into-a-water-fountain-gm1278125918-377163413

(a) Name the physics phenomenon that causes the coins to appear closer to the surface than they actually are.

Apparent depth.

(b) The following diagram shows the light ray as it leaves the water. The refractive index of water is 1.33 and air is 1.00.




Calculate the angle $\theta$, shown at the surface of the water.

$n_i = 1$ $\quad \theta_1 = 40$ $\quad n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_2 = 1.33$ $\quad \theta_2 = ?$ $\quad 1 \sin 40 = 1.33 \sin\theta_2$

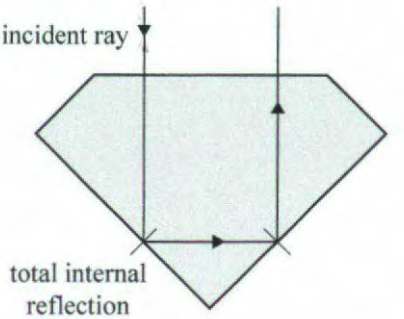
$\theta_2 = 28.9°$

(c) The students notice a diamond in a jeweller's shop. They know total internal reflection is the main cause of the sparkle of the diamond.

Refractive index of diamond = 2.42

Critical angle of diamond = 24.4°

Speed of light in air = $3.00 \times 10^8$ m s$^{-1}$



A ray of light passes through the boundary between air and the diamond.

(i) Calculate the speed of light in the diamond.

$n_1 = 1$ $\quad V_1 = 3 \times 10^8$ $\quad \frac{n_1}{n_2} = \frac{V_2}{V_1}$

$n_2 = 2.42$ $\quad V_2 = ?$

$\frac{1}{2.42} = \frac{V_2}{3 \times 10^8}$

$V_2 = 3 \times 10^8 \times \frac{1}{2.42} = 1.24 \times 10^8 \text{ ms}^{-1}$

(ii) State what happens to the frequency of the light as it passes into the diamond.

The frequency ~~is constant~~ does not change.

(d) (i) Using appropriate calculations, show that the critical angle for diamond is 24.4°.

$n_1 = 1$ $\quad \theta_1 = 90$ $\quad n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_2 = 2.42$ $\quad \theta_2 = ?$ $\quad 1 \sin 90 = 2.42 \sin\theta_2$

$\sin^{-1}\left(\frac{1}{2.42}\right) = \theta_2$

$\theta_2 = 24.4°$

(ii) Explain total internal reflection in terms of the conditions required, and include a definition of the critical angle.

The ray must move from a higher refractive index to a lower refractive index. When the incident ray is equal to the critical angle the ray bends 90° away from the normal and travel along the boundary. The critical angle is the incident angle that allows the ray to bend 90°. away from normal.

## QUESTION THREE: THE OPTICIAN

The students decide to try out some prescription glasses. They try out two types of glasses, both of the same shape and material but with different thicknesses.

Thick lens
www.aliexpress.com/i/4001151117795.html

Thin lens
www.amazon.in/Artificial-Glass-Crystal-Watchmakers-Accessories/dp/B09ZTT7C19

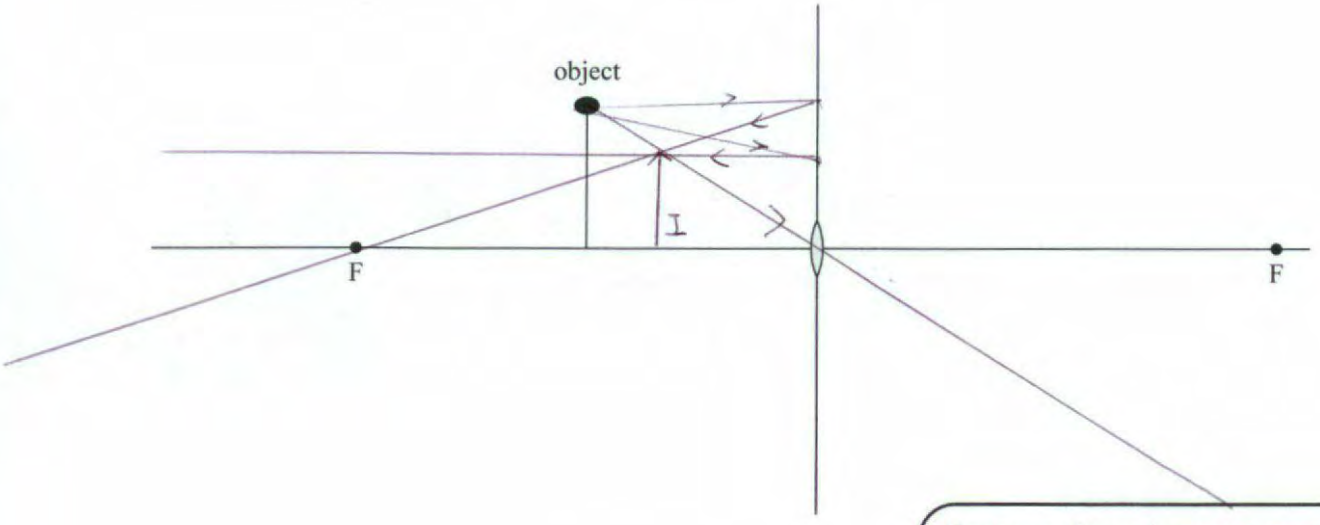
(a) How does the focal length of the thin lens compare to the focal length of the thick lens?

*No calculation required.*

The thicker lens will have a longer focal length.

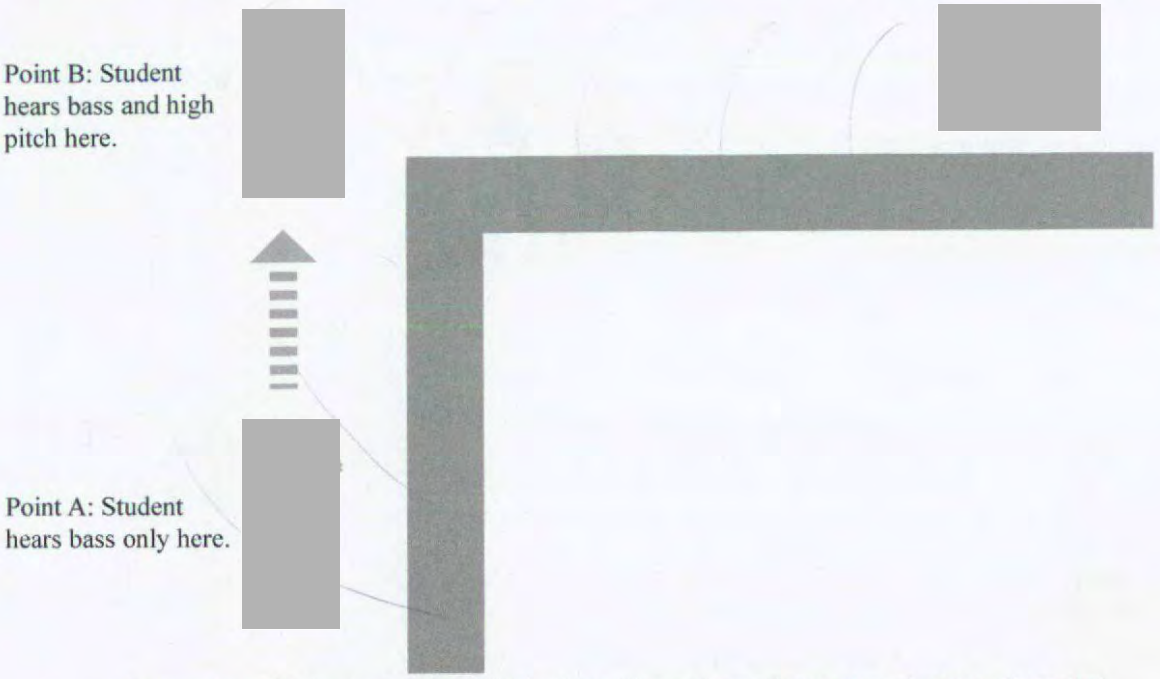
(b) A different set of glasses has convex lenses with focal length 30 cm.

Complete the ray diagram below to show the position and appearance of the image produced.




*If you need to redraw your response, use the diagram on page 11.*

(c) The students walk further along the mall and hear music playing from a radio around the corner. At point A they only hear the low pitch of a bass guitar, and cannot work out the tune. At point B they hear the bass guitar and the high pitch of an electric guitar playing the same track of music.




Sources: www.kindpng.com/imgv/iiRhiJh_ykle-caillou-cartoon-asian-cartoon-characters-disney-hd/
https://whyy.org/articles/seaside-heights-bans-loud-music-on-beaches/

Why do they hear the bass guitar and not the electric guitar at point A, even though they are both at the same volume?

Your answer should identify the physics phenomenon, and explain the effect of the corner on this process.

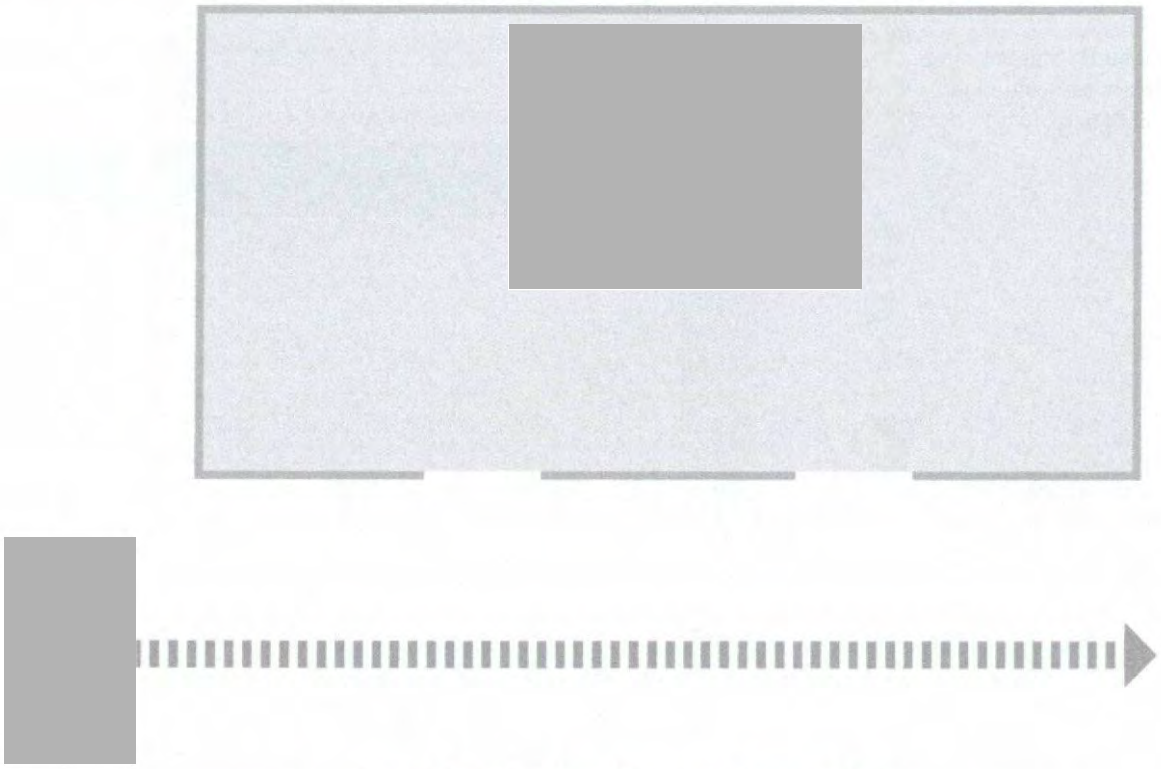
You may use the diagram above to support your answer.

*If you need to redraw your response, use the diagram on page 11.*

The student can ~~hear~~ only hear bass at point A because the wavelength of the bass is larger than high pitch of an electric guitar. The larger the wave length the more it diffracts. the waves will diffract around the corner and the bass that diffracts more will only reach up to point A. whereas in ~~Point~~ Point B the student can hear both because ~~she~~ it is at the position where the high pitch wave don't need to diffract as much so the both sound will reach to her.

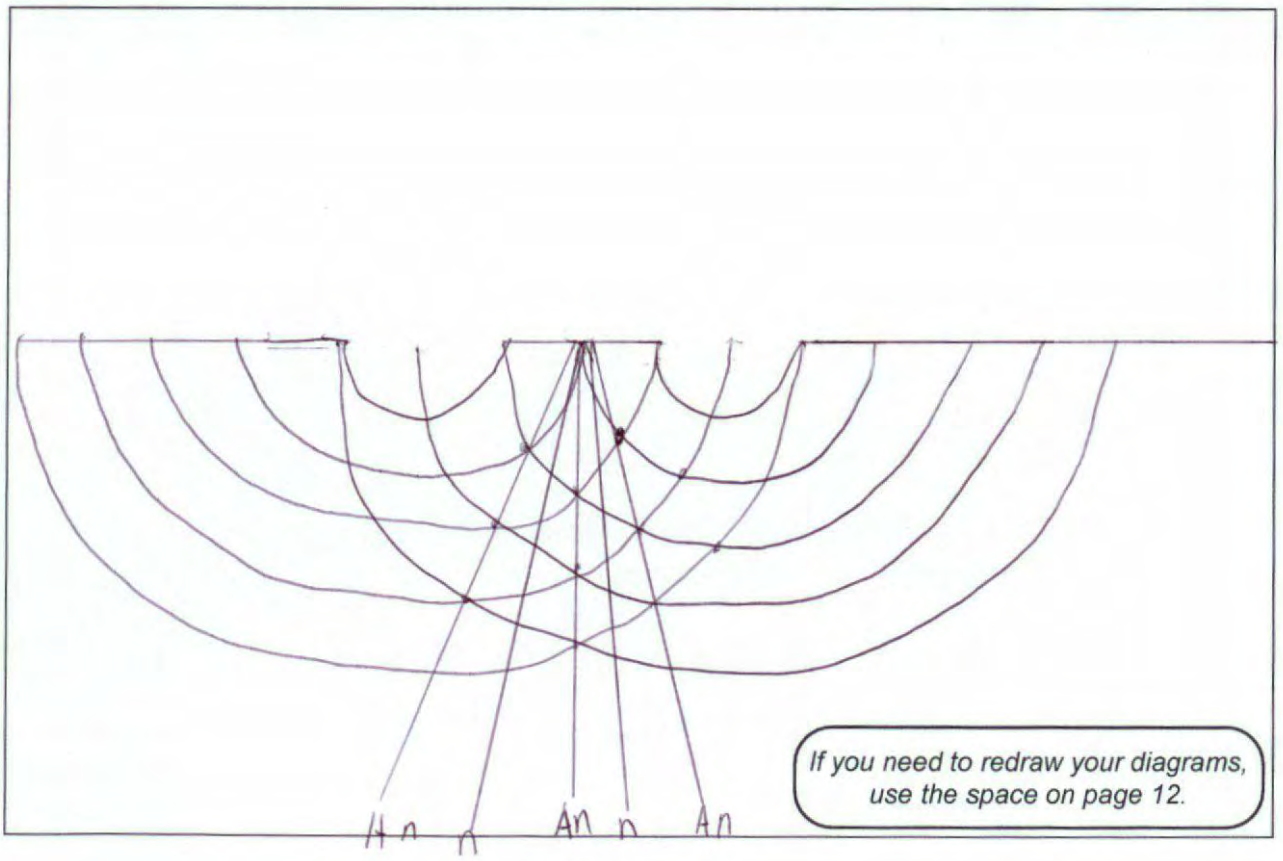
*Question Three continues on the next page.*

(d) Later they pass by the hall where a band is tuning their instruments and playing a single frequency. The hall has two open doors. The students notice the sound appears to vary in volume as they walk past the doors. Assume the tuning frequency is played at a constant volume.



Sources: https://www.pngwing.com/en/free-png-njmzc
www.kindpng.com/imgv/iiRhiJh_ykle-caillou-cartoon-asian-cartoon-characters-disney-hd/

Through the use of appropriate diagrams and the use of physics concepts, identify, describe, and explain the physics phenomena that are taking place to cause the sound to vary in volume.




*If you need to redraw your diagrams, use the space on page 12.*

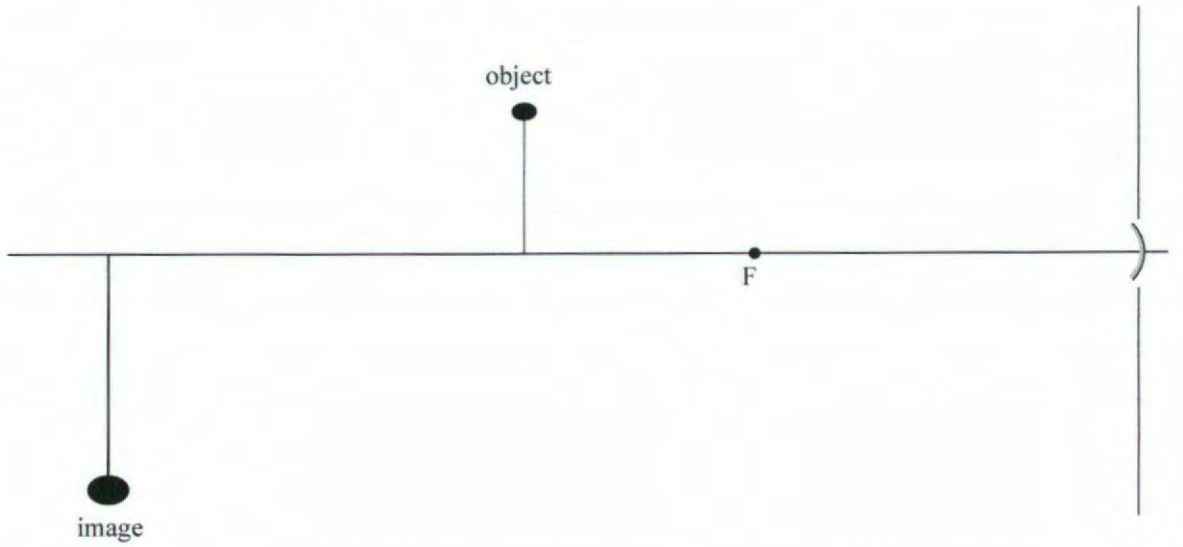
As the waves go through the wall, they ~~refract~~ diffract and form a circular wavefronts. These waves overlap and form an interference pattern of...

- Nodal lines where waves meet 180° out of phase and destructively interfere. ~~waves~~ peaks meet ~~peaks~~ troughs and trough meets ~~trough~~ Peaks. The amplitude is ~~smaller~~ zero so she will hear the music quiter.

- Antinodal lines where waves meet in phase and constructively interefere. Peeks meet Peaks and trough meets troughs. The amplitude is larger so she will hear the music louder.

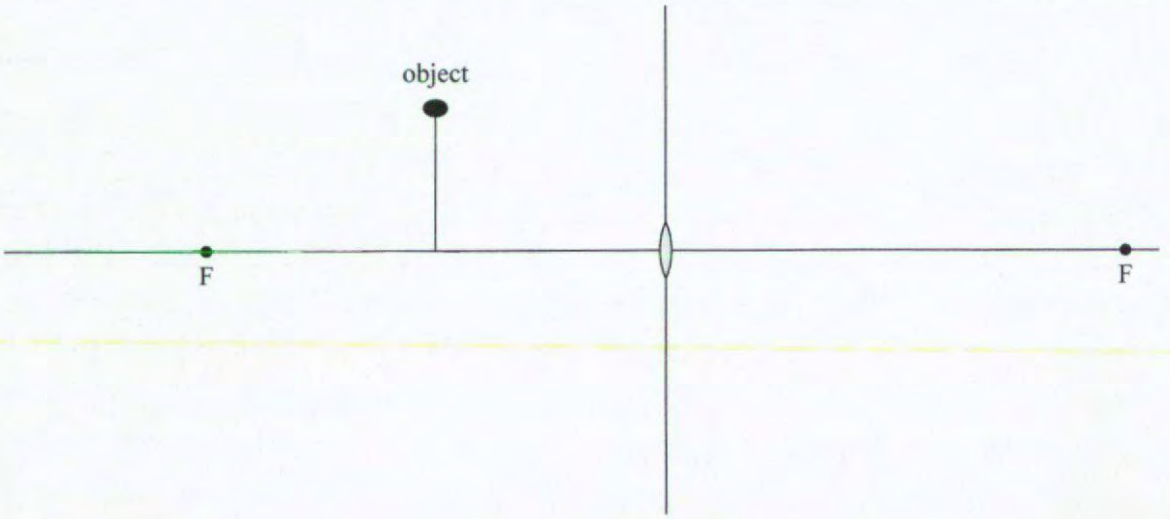
## SPARE DIAGRAMS

If you need to redraw your response to Question One (b), use the diagram below. Make sure it is clear which answer you want marked.

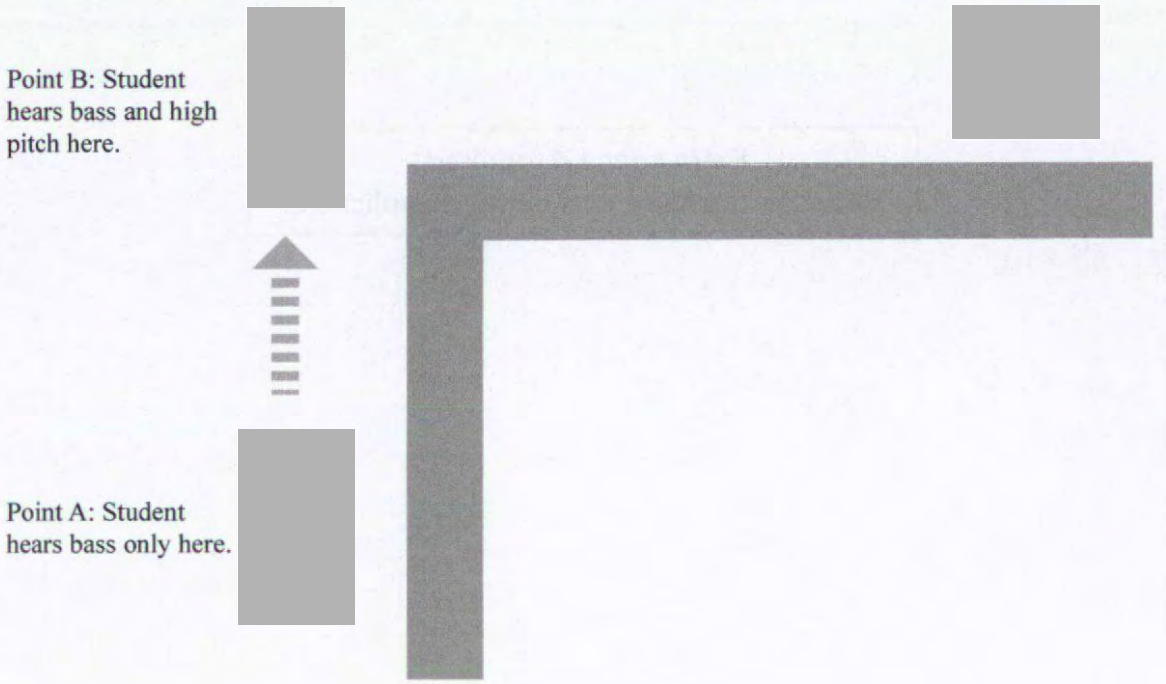



If you need to redraw your response to Question One (d), use the space below. Make sure it is clear which answer you want marked.

If you need to redraw your response to Question Three (b), use the space below. Make sure it is clear which answer you want marked.




If you need to redraw your response to Question Three (c), use the space below. Make sure it is clear which answer you want marked.



If you need to redraw your diagrams for Question Three (d), use the space below. Make sure it is clear which answer you want marked.

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

QUESTION NUMBER

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

QUESTION NUMBER

# Merit

**Subject:** Physics

**Standard:** 91170

**Total score:** 18

| Q | Grade score | Marker commentary |
|---|---|---|
| One | M6 | A poor definition of ‘real image’ and incomplete calculation of magnification in part (c) prevented a higher grade. |
| Two | M6 | Incorrect physics phenomenon for part (a) and incorrect angle of refraction used in (b), together with a missed condition for total internal reflection led to merit only. |
| Three | M6 | Incorrect answers for the lens parts but redeemed by good answers on the more difficult diffraction and 2-point source interference aspects. |