SUPERVISOR'S USE ONLY

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

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. 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.

Excellence 24

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.

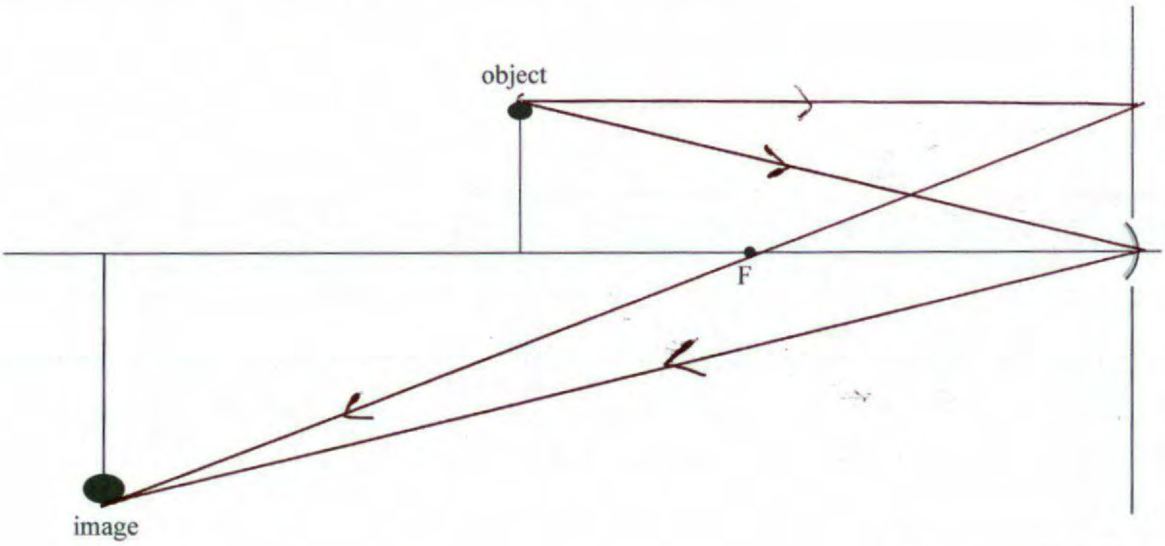
The students start looking at hats in a concave mirror of focal length 25 cm. The mirror image is initially real.

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

The image is made of light & is before the mirror. A real image can be projected on a screen

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.



(c) Calculate the magnification of the image formed.

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

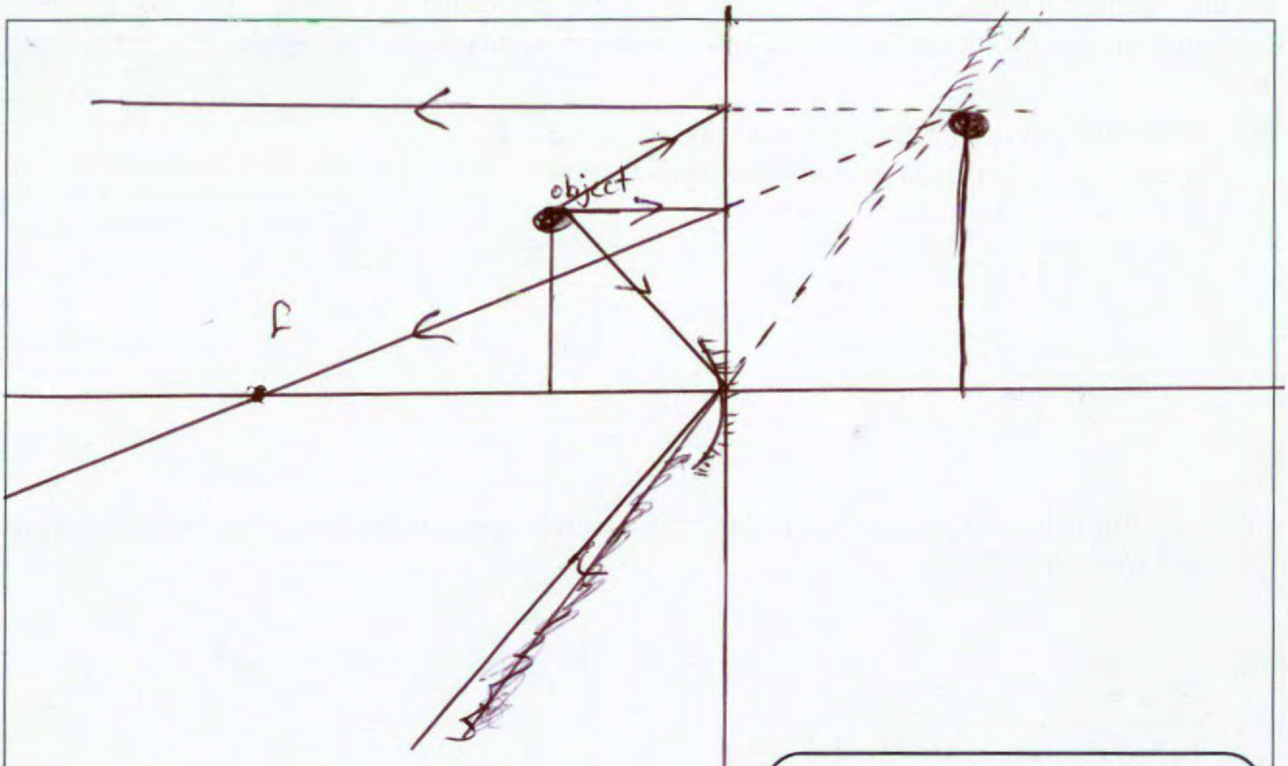
$m = \frac{d_i}{d_o}$ $\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$ $\frac{1}{d_i} = \frac{1}{0.25} - \frac{1}{0.4} = \frac{3}{2}$

$d_i = \frac{2}{3} = 0.67\,m$

$m = \frac{0.67}{0.4} = 1.675$

(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.

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ $\quad \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{0.25} - \frac{1}{0.1} = \frac{-6}{1}$

$d_i = \frac{1}{-6} = -0.167\text{m}$ this means that the image is virtual

$m = \frac{d_i}{d_o} = \frac{0.167}{0.10} = 1.67$ greater than 1 is enlarged

the image is also upright.

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QUESTION TWO: THE WISHING POND

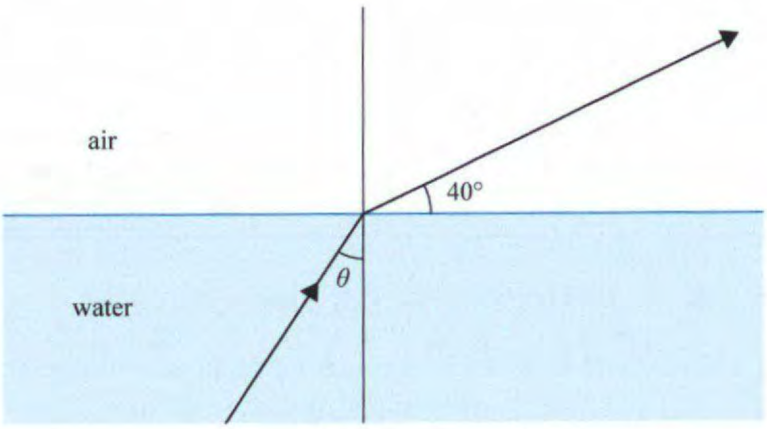
The students walk past a wishing pond for a local charity. People throw coins into the water, and these are collected at the end of the day. As the students sit on the side of the pond, they notice the coins appear closer to the surface of the water than they actually are.

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.

refraction

(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 θ, shown at the surface of the water.

$\theta_2 = 50^\circ$ $\theta_1 = ?$ $n_1 = 1.33$ $n_2 = 1$

θ_1 - $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$ (3SF)

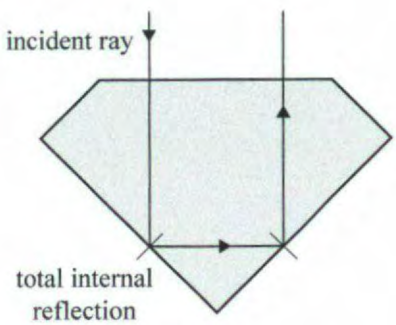
$\theta_1 = \sin^{-1}\left(\frac{1 \times \sin(50)}{1.33}\right) = 35.2^\circ$

(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 = 3.00×10^8 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.

$\frac{n_1}{n_2} = \frac{V_2}{V_1}$ $V_2 = \frac{1 \times 3\times10^8}{2.42} = 1.2\times10^8 ms^{-1}$

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

The frequency remains the same when it changes medium. $\frac{V_2}{V_1} = \frac{\lambda_2}{\lambda_1}$ the wavelength changes at the same rate as the speed $V = f\lambda$ constant. changes at the same rate

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

$n_1 \sin(\theta_1) = n_2 \sin\theta_2$ the critical angle is the incident angle when refracted to 90°

$2.42 \times \sin(\theta_c) = 1\times\sin(90)$ $\theta_c = \sin^{-1}\left(\frac{\sin(90)}{2.42}\right)$

$\theta_c = 24.4^\circ$ (3sf)

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

Total Internal Reflection is when an ray instead of refracting reflects. This happens when a ray is going from more optically dense to less & the angle of incidence is greater than the critical angle. The critical angle is the angle of incidence when refracted to 90°. When θ_i is greater than θ_c it can no longer refract away from the normal as that is greater than the boundry this means that it will reflect instead.

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

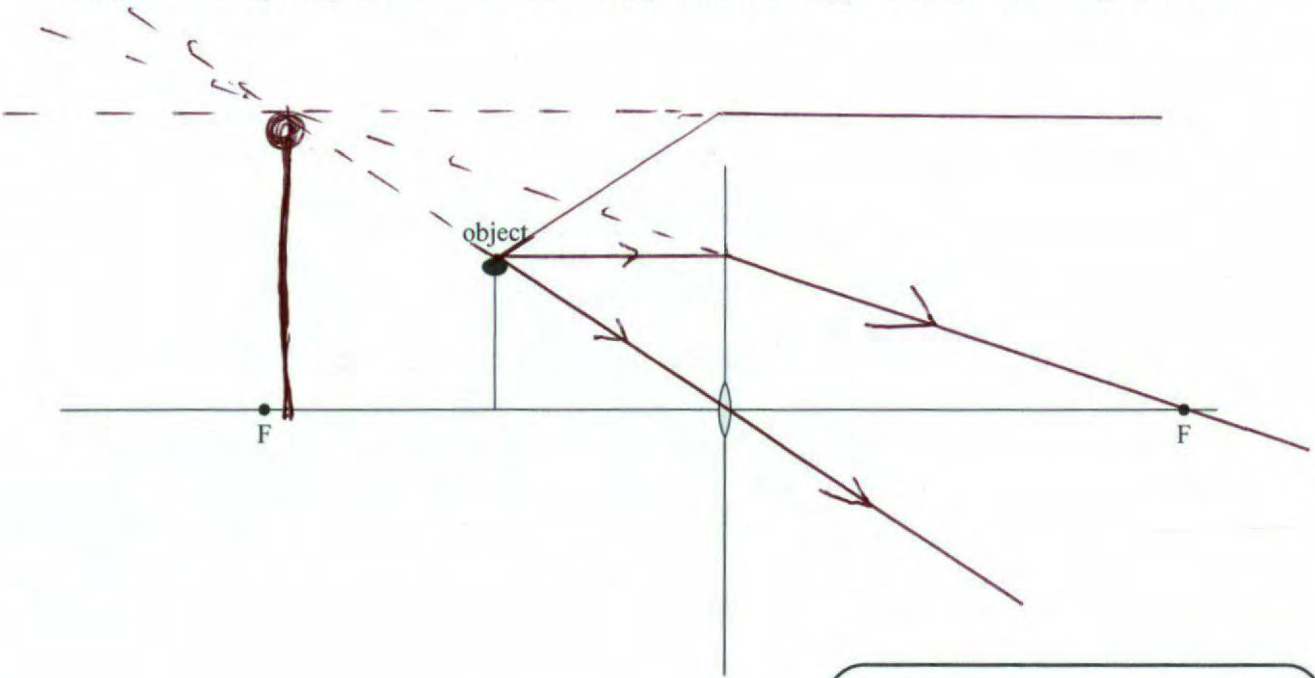
Thin lens
www.amazon.in/Artificial-Glass-Crystal-Watchmakers-Accessories/dp/B09ZTT7C19

(a) How does the focal length of the thin lens compare to the focal length of the thick lens?
No calculation required.

The thick lense has a closer focal point.

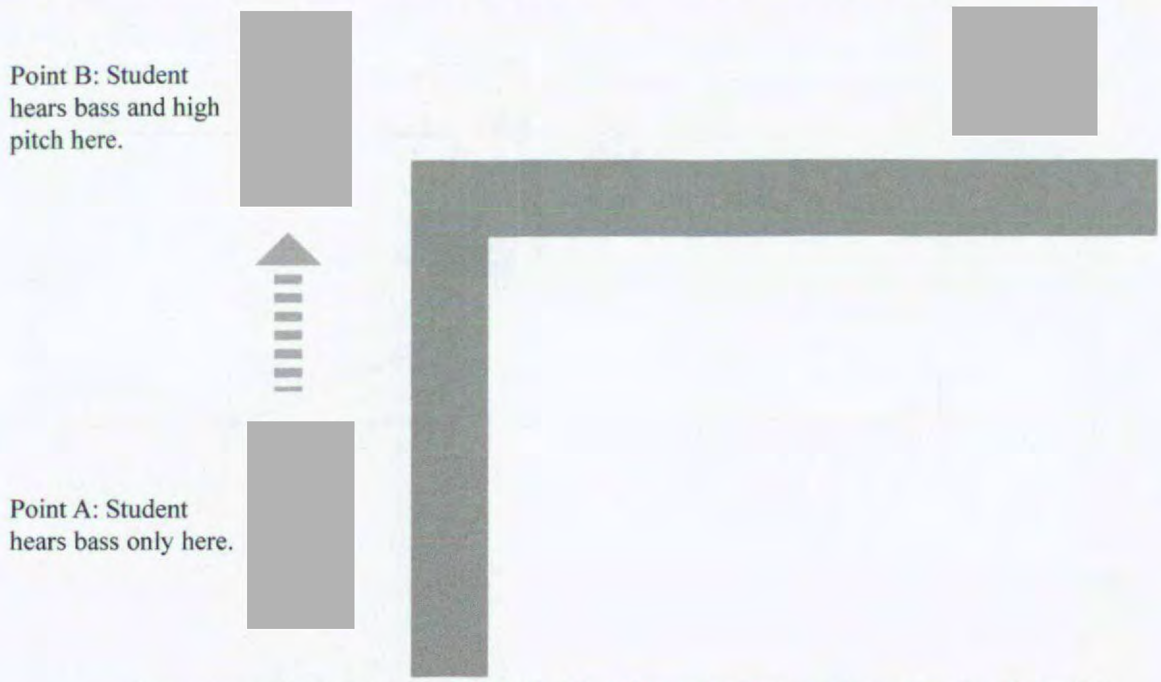
(b) A different set of glasses has convex lenses with focal length 30 cm.

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.

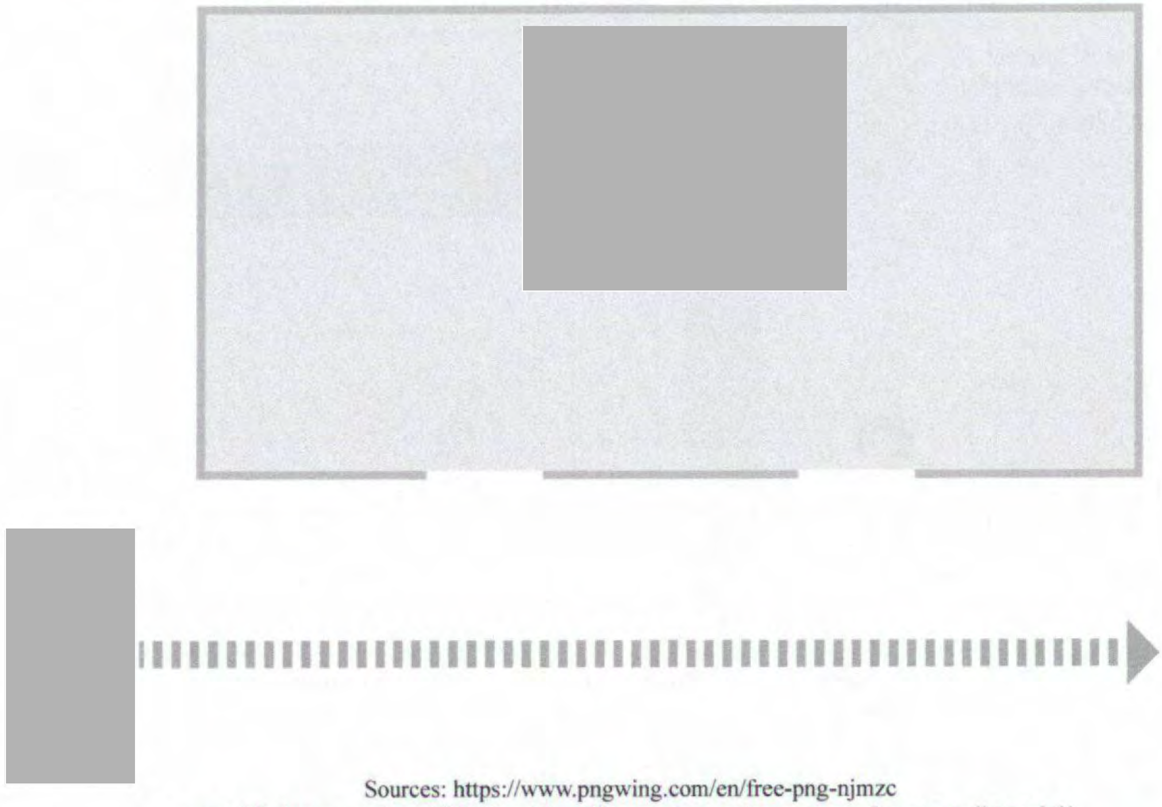
You may use the diagram above to support your answer.

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

The bass ~~gu~~ gaitar is a lower pitched instrument meaning it has a larger wavelength, the sound from the speaker must diffract around the corner to meet the student in point ~~A~~. this means that the sounds with a larger wavelength like the bass ~~gu~~ guitar will diffract more around the corner because larger wavelengths diffract more. when the student reaches point B the sound does not need to diffract as much ~~and it can be heard~~ the higher pitched guitar can be heard.

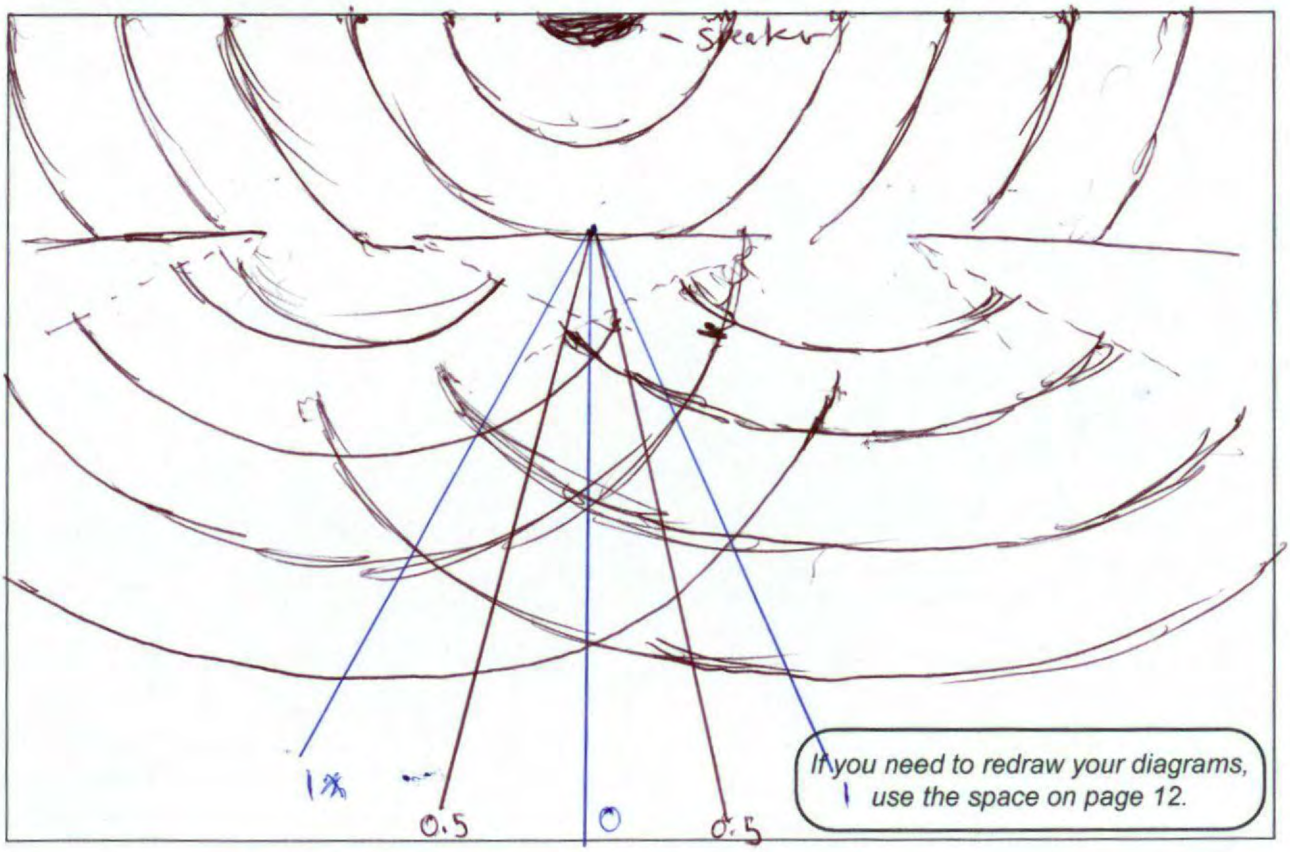
Question Three continues on the next page.

(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.

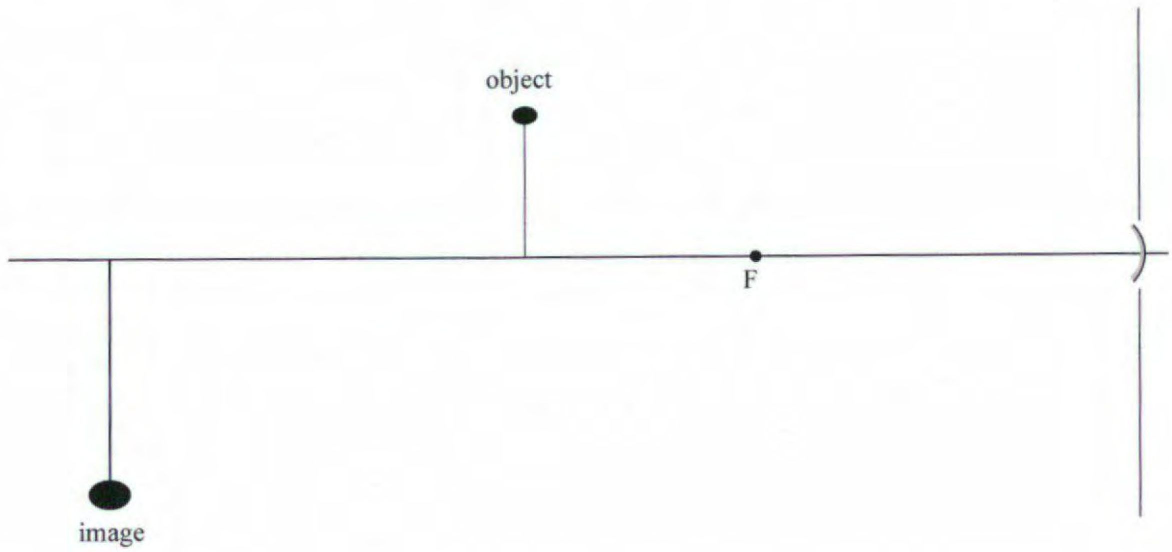


If you need to redraw your diagrams, use the space on page 12.

When the speakers sound reaches the door ways it diffracts around them creating two sources of identical sound waves. When these waves intercept Interference occurs. The nodal lines (black) are 180° out of phase so the amplitude is 0 & deconstructive interference occurs. the nodal lines have path differences of 0.5, 1.5, 2.5 3.5 etc. the Antinodal lines are when constructive ~~inter~~ interference occurs. these lines (blue) are in phase with path differences of (0, 1, 2, 3 etc). when the students walks past the doors they will hearer differente volumes. When walking through anti nodal lines the volume will be louder because antinodal lines have double the amplitude. when walking through the nodal lines the sound will be much more ~~quiet~~ quieter because the amplitude is decreased. the sound will also increase as they get closer to the doors because the sound doesn't have to travel as far.

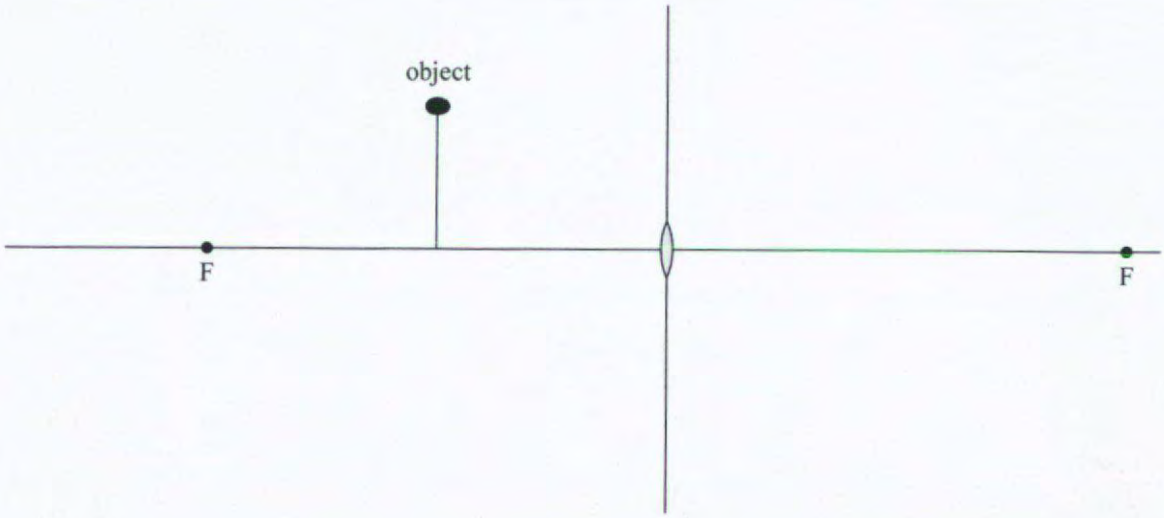
SPARE DIAGRAMS

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.

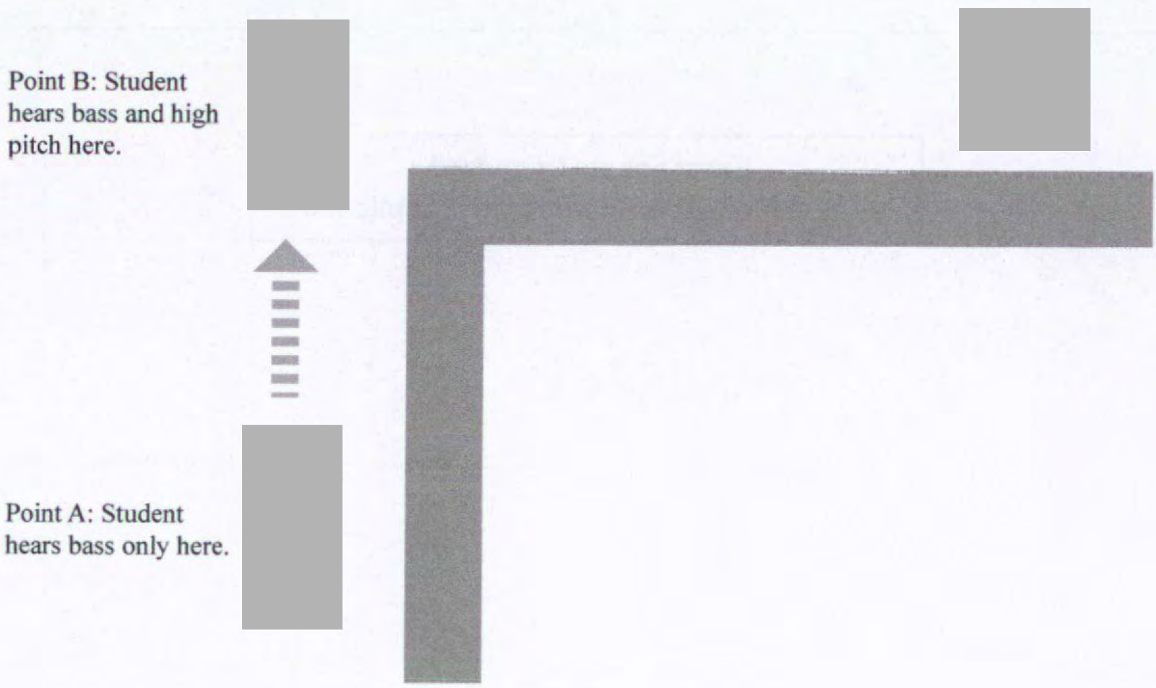


If you need to redraw your response to Question One (d), use the space below. Make sure it is clear which answer you want marked.

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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QUESTION NUMBER

91170

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Excellence

Subject: Physics

Standard: 91170

Total score: 24

Q	Grade score	Marker commentary
One	E8	Answered completely, with mirror diagrams showing appropriate rays (including arrows) and comprehensive calculations and explanations.
Two	E8	All calculations correct (including using correct angle of refraction) with units and full explanation of total internal reflection.
Three	E8	Shows thorough understanding of lenses, diffraction and 2-point source interference through appropriate descriptions and diagrams.