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91170



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

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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Physics 2025

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.

Show ALL working.

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 the margins (✂/✂/✂). 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

TOTAL 17

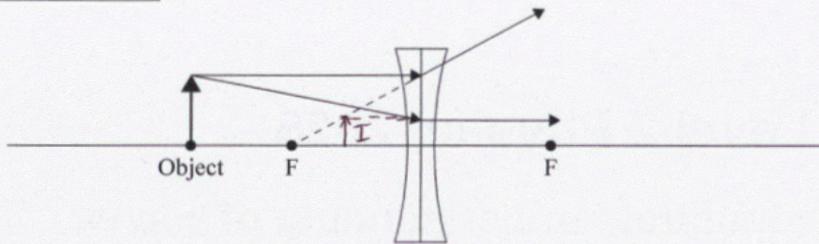
QUESTION ONE: LENSES

Data projectors in classrooms use a concave lens as part of their projection system.

One such projector has an object which is 15 cm from a concave lens with focal length 10 cm.

- (a) Draw and label the image in the diagram below.

Diagram is
NOT to scale



Source: <https://sitech.co.nz/products/projectors-screens/data-projectors/epson-eb-w06-data-projector>

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

- (b) (i) Calculate the magnification of the image.

$$f = 10 \quad d_o = 15 \quad d_i = ?$$

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

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

$$\frac{1}{10} - \frac{1}{15} = \left(\frac{1}{30}\right)^{-1} = 30$$

$$m = \frac{d_i}{d_o}$$

$$m = \frac{30}{15}$$

$$m = 2$$

- (ii) Fully describe the nature of the image formed.

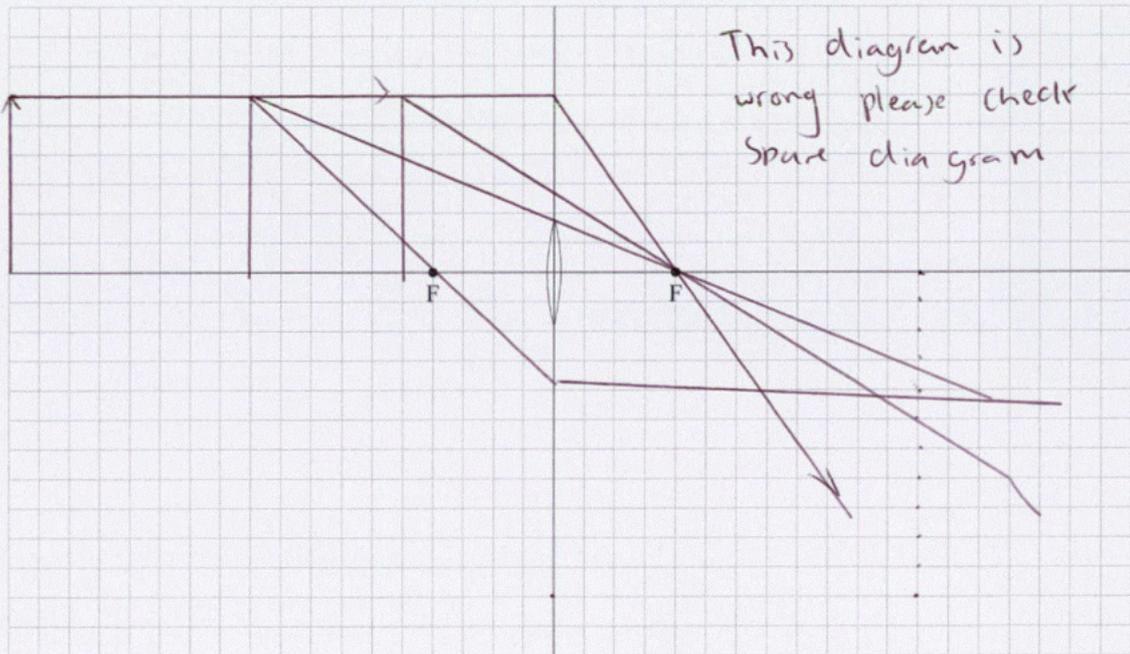
Virtual, upright, and diminished

- (c) In another projector, a convex lens is used, and a real image twice as big as the object is formed.

Complete a ray diagram on the grid below to show how the real image that is twice as big as the object is formed.

You must show any calculations you used to decide where to place the object.

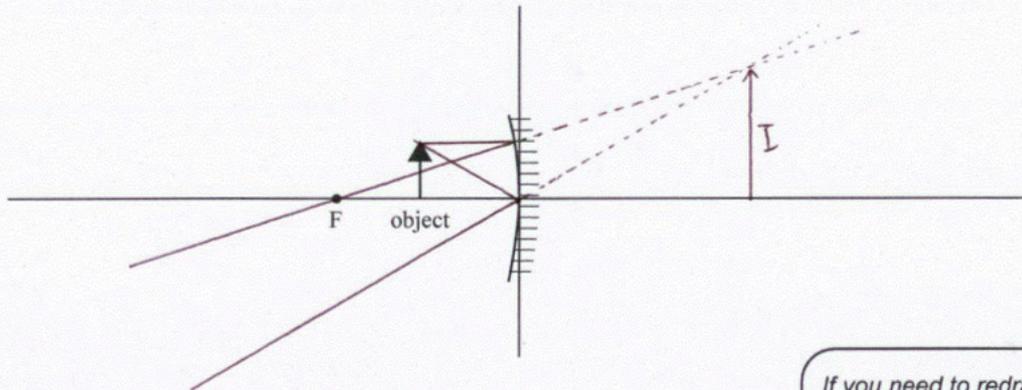
Make the object 6 squares tall:



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

- (d) An ultra-short-throw projector shortens the projection distance, and still produces high-quality images by using a concave mirror that reflects the light and focuses on the screen.

- (i) Complete the ray diagram below to find and draw the image.



If you need to redraw your response, use the diagram on page 12.

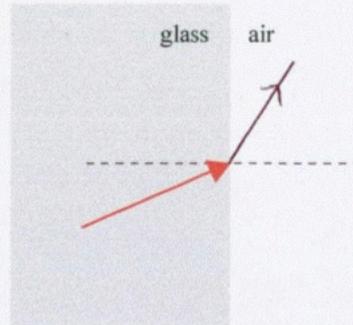
- (ii) Describe the nature of the image formed by the concave mirror.

Virtual, upright, enlarged

QUESTION TWO: REFRACTION

A double-glazed window has two glass panes with a refractive index of 1.5, separated by an air gap. Maiti notices that a red laser shone through the window does not travel straight through.

- (a) On the diagram below, show the path of the ray of light as it crosses from one glass pane to the air.



Source: <https://hestiad.com/windows-101-window-frame-materials-and-glass-options/>

If you need to redraw your response, use the diagram on page 12.

- (b) Explain what a refractive index of 1.5 means, in terms of the speed of light in the glass.

refractive index mean how much the speed of light changes in that medium which cause it to bend closer or away from the normal. In this the glass medium is denser the the ~~angle~~ angle of incidence will be smaller than the angle of reflection and the speed of light is slower in glass

- (c) Red laser with wavelength 6.50×10^{-7} m enters a **different** window at an incident angle of 30° . The wavelength of the red light in the glass is 4.64×10^{-7} m.

Calculate the angle of refraction as the red laser passes from air ($n = 1.0$) into the glass.

$$n_1 = 1 \quad n_2 = \text{?} \quad \theta_i = 30 \quad \theta_2 = ?$$

$$\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1}$$

$$\theta_2 = \sin^{-1}\left(\frac{1 \sin 30}{0.71}\right)$$

$$= 44.77^\circ$$

$$\frac{1}{n_2} = \frac{4.64 \times 10^{-7}}{6.50 \times 10^{-7}}$$

$$= 44.77^\circ$$

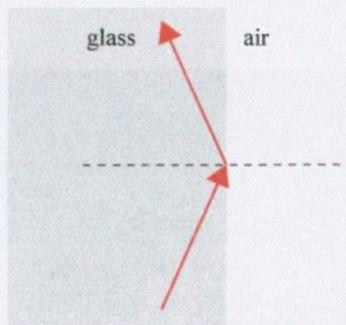
$$\frac{1}{n_2} = 0.71$$

$$n_2 = 0.71$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$1 \sin 30 = 0.71 \sin \theta_2$$

- (d) Matiu notices that if he keeps increasing the angle, the ray of light bounces off the inner surface of the glass, as shown in the diagram below, and none enters the air.



Source: https://en.m.wikipedia.org/wiki/File:TIR_in_PMMA.jpg

- (i) Name the phenomenon that is occurring.

Total internal reflection

- (ii) Describe the conditions needed for this phenomenon to occur.

Calculations are not needed.

First condition is that the ray has to be going from a more denser medium to a less denser medium and secondly the angle of incidence has to be more than the critical angle so that the angle of reflection can be 90° or perpendicular to the normal. ~~so~~ so then the ray will bounce back into the more denser medium.

QUESTION THREE: WAVES

Wireless internet connections (Wi-Fi) work by sending information as electromagnetic waves through the air.



Source: <https://www.linkedin.com/pulse/how-choose-right-ai-ml-use-cases-obtain-benefits-approach-dharra>

- (a) What type of wave is an electromagnetic wave?

transverse

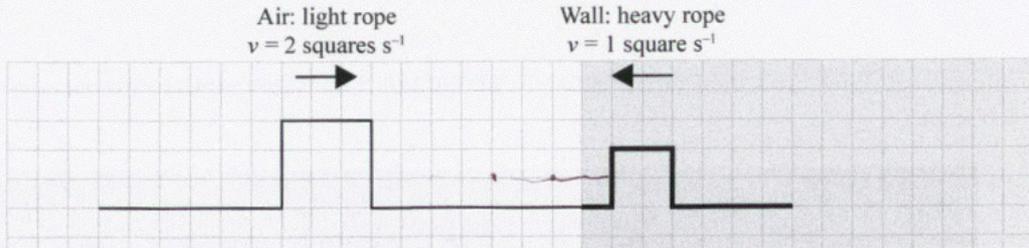
- (b) Wi-Fi interference can be an issue in a populated school environment. This occurs when two or more Wi-Fi access points are using the same channel or frequency, causing interference and reducing the reliability of the Wi-Fi.

Explain how having two Wi-Fi access points emitting waves of the same frequency can cause both spots of strong Wi-Fi signal and spots of weak Wi-Fi signal.

When a crest and crest ~~or~~ or trough and trough ~~are~~ from 2 waves ^{interfering} ~~meet~~ that means that they are in phase and so there is constructive interference, and when there is crest and trough or trough and crest ~~that~~ interfering that means that they are out of phase and so there is destructive interference. So when there is a spot of constructive interference those spot will have a stronger signal and when there is a spot of destructive interference that spot will have a weaker signal. The path difference for constructive interference is $n\lambda$

- (d) When Wi-Fi signals pass through walls, they slow down. The boundary between wall and air can be modelled by ropes of different densities joined together.

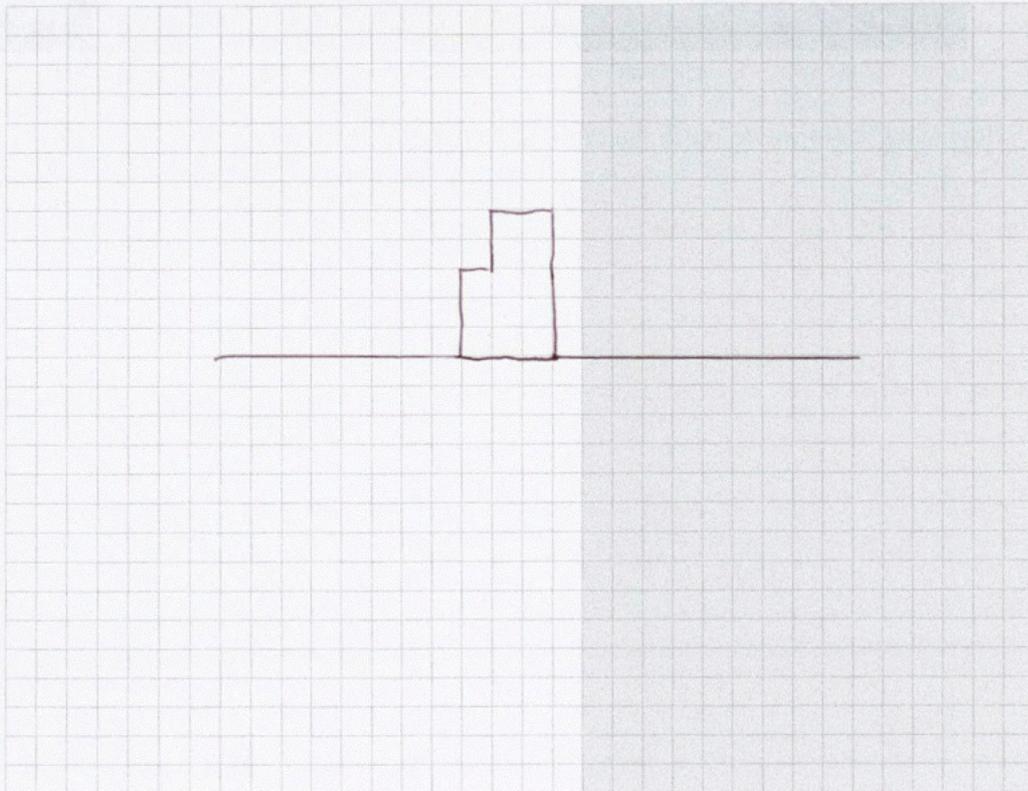
The diagram below models two pulses from two Wi-Fi points travelling towards each other. The speed in air is 2 squares per second, and the speed in the wall is 1 square per second.



- (i) Describe how the frequency of the Wi-Fi signal changes as it moves from air to wall.

no matter the medium the frequency will always be the same / constant

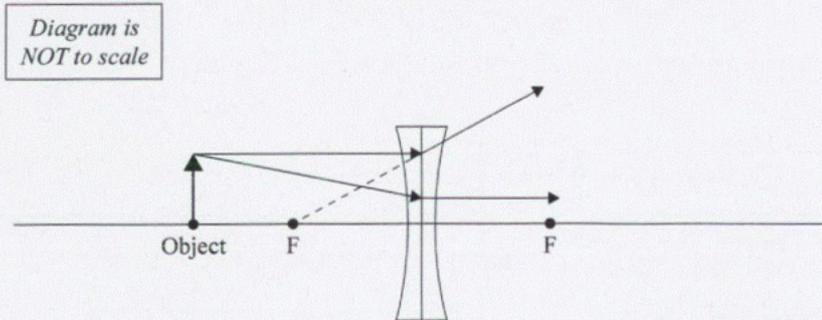
- (ii) Assuming any pulse is half the height of the original after it transmits and reflects with the boundary, draw the result of the two pulses' interactions after 3 seconds.



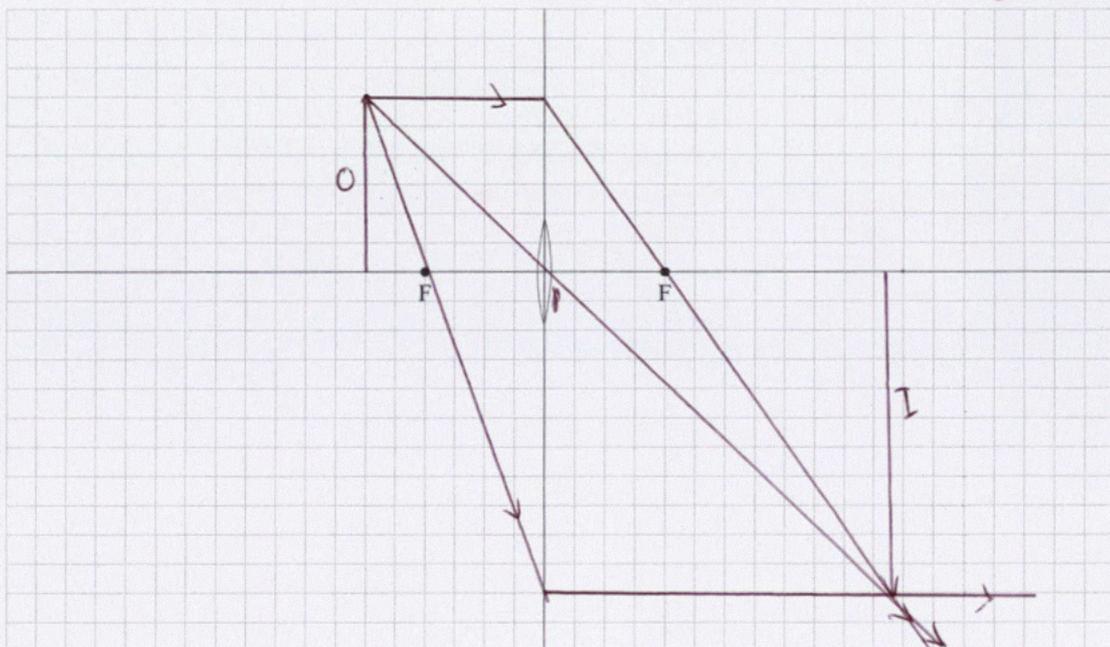
If you need to redraw your response, use the diagram on page 13.

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



Merit

Subject: L2 Physics

Standard: 91170

Total score: 17

Q	Grade score	Marker commentary
One	M5	Correct image located for (a), incorrect f (should be -10 cm), the rest of (b) is correct. Incorrect diagram for (c) and no calculation. Part (d) correct diagram and description.
Two	M6	Refracted ray correctly drawn for (a). In (b) slower speed but no qualitative answer. Correct ratio calculated in (c) but wrongly substituted, hence wrong angle calculated. Part (d) identifies total internal reflection correctly, but uses 'density' not refractive index for one phenomenon.
Three	M6	Transverse wave correct for (a). Fully discusses interference in (b) and links signal strength to path difference. Part (c) was not attempted. States that frequency remains unchanged in (d) and gets one of the pulses correct after 3 seconds.