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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 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.**

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## QUESTION ONE: LENSES

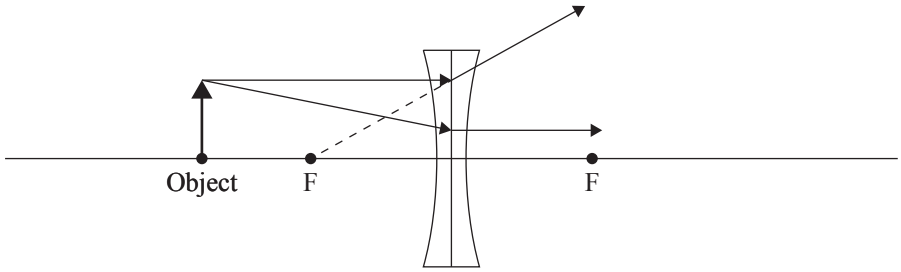
Data projectors in classrooms use a concave lens as part of their projection system.

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

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

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

*Diagram is NOT to scale*




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

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

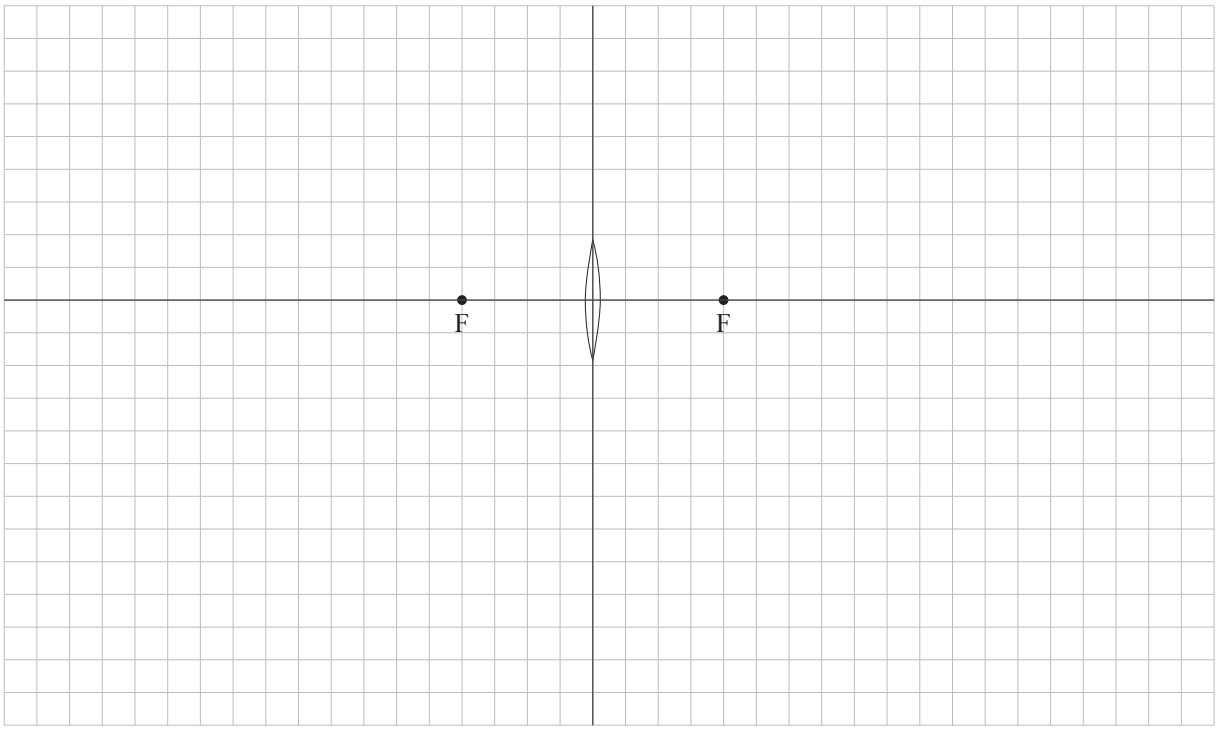
(ii) Fully describe the nature of the image formed.

(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.*

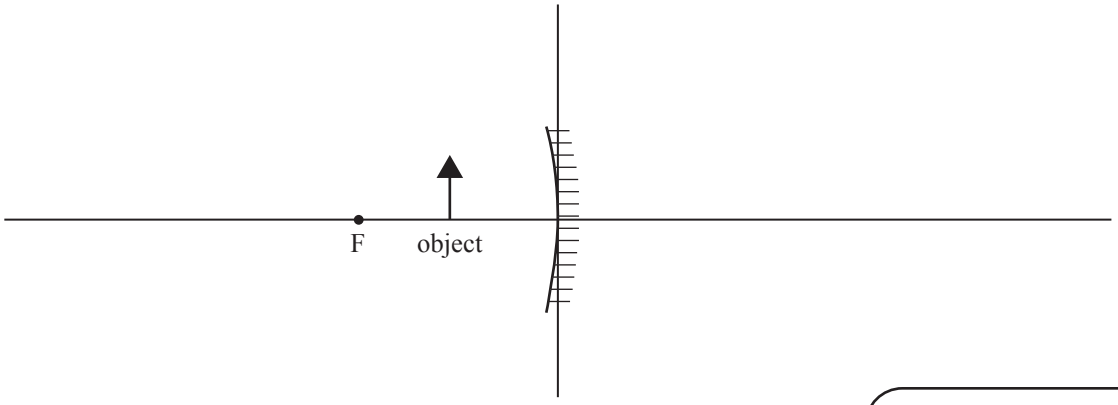
*Make the object 6 squares tall:*




*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.

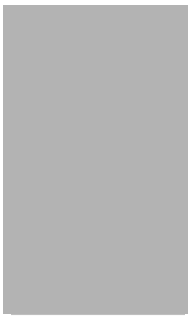



*If you need to redraw your response, use the diagram on page 12.*

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

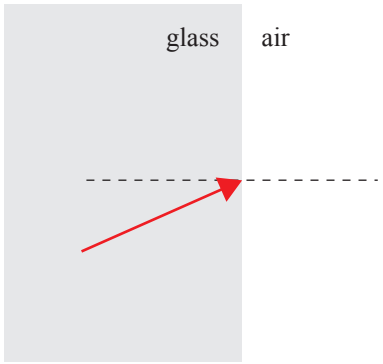
## QUESTION TWO: REFRACTION

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



Source: https://hestiadc.com/windows-101-window-frame-materials-and-glass-options/

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



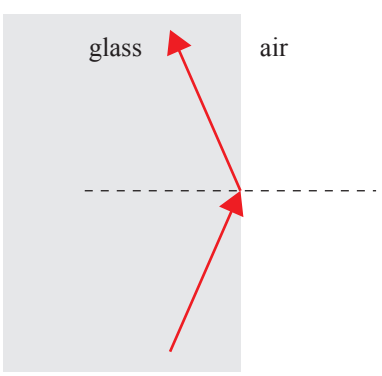

*If you need to redraw your response, use the diagram on page 12.*

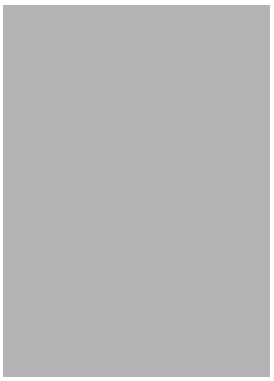
(b) Explain what a refractive index of 1.5 means, in terms of the speed of light in the glass.

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

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

(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.

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

*Calculations are not needed.*

## 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?

(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.

(c) Internet satellites orbit the Earth at a height of 550 km. The wavelength of the radio wave is 0.025 m.

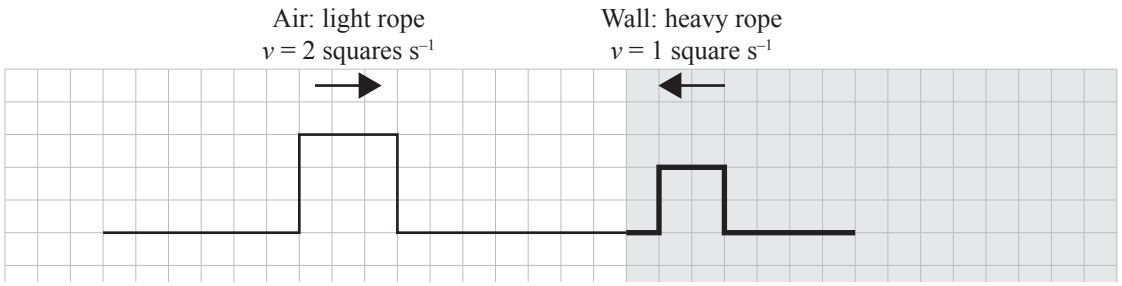
Source: https://researchoutreach.org/articles/satellite-internet-technology-double-edged-sword/

How many radio waves reach the Earth in 2 hours?

*Question Three continues on the following page.*

(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.

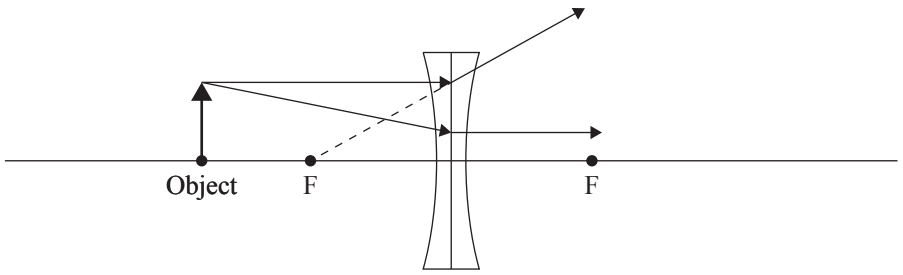
(ii) Assuming any pulse is half the height of the original after it transmits and reflects with the boundary, draw the result of the two pulses' interactions after 3 seconds.

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

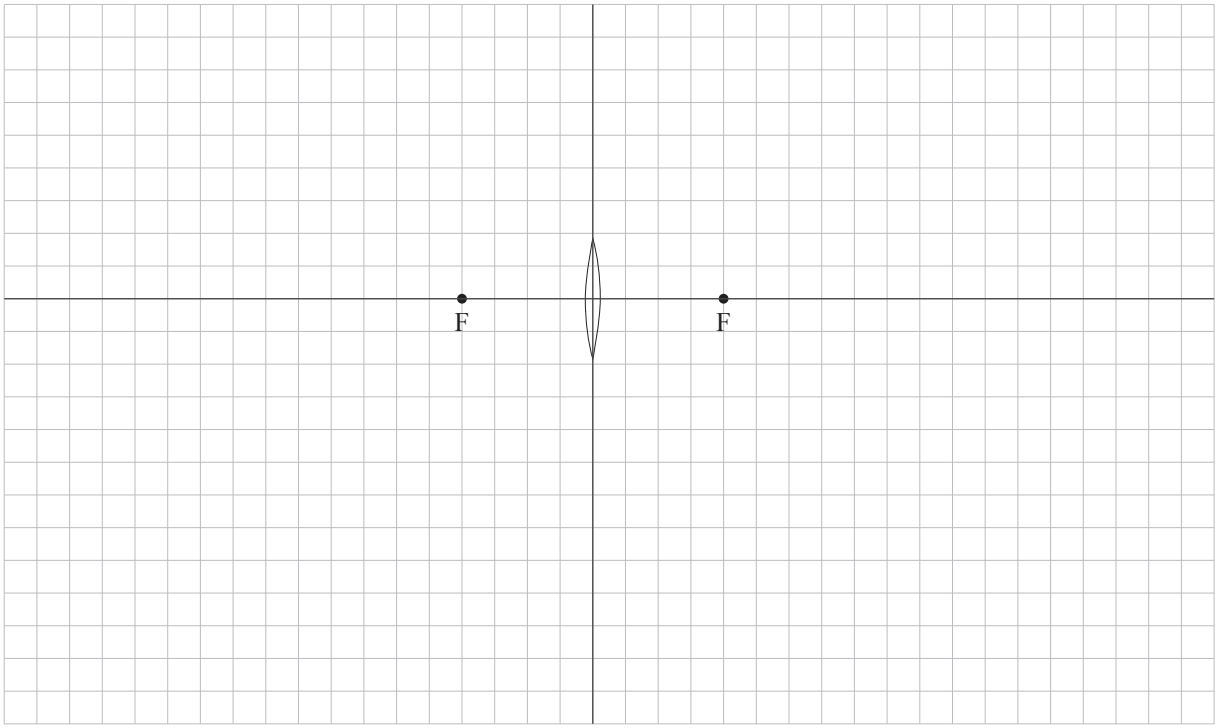
## SPARE DIAGRAMS

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.

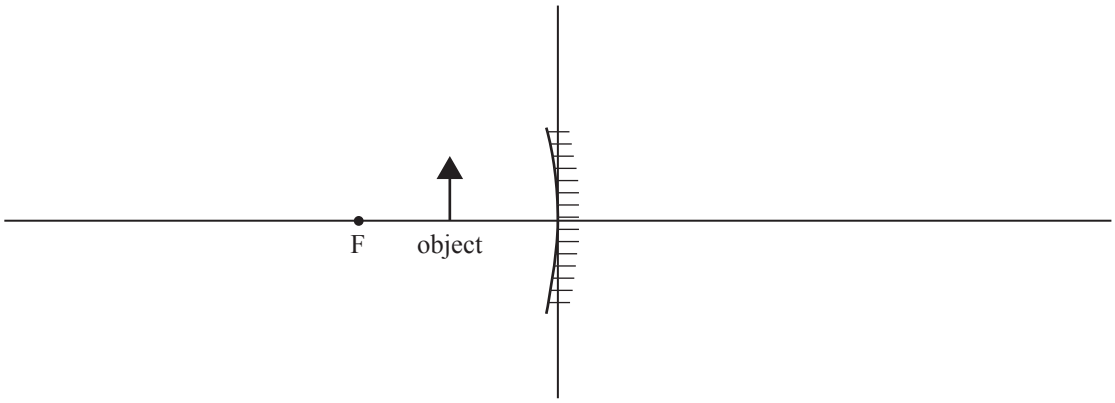
*Diagram is NOT to scale*



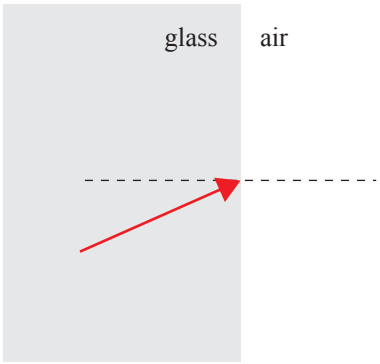

If you need to redraw your response to Question One (c), use the diagram below. Make sure it is clear which answer you want marked.



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




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



If you need to redraw your response to Question Three (d)(ii), 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

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

QUESTION NUMBER

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

QUESTION NUMBER