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91170

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NEW ZEALAND QUALIFICATIONS AUTHORITY
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Level 2 Physics, 2019

91170 Demonstrate understanding of waves

9.30 a.m. Friday 8 November 2019
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 space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–12 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.

TOTAL

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QUESTION ONE: SATELLITE DISHES

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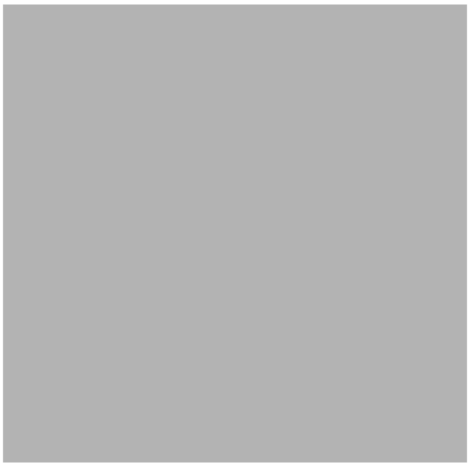
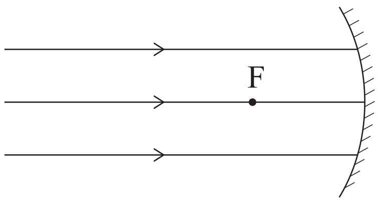
Satellite communications can help isolated communities stay in touch, as well as improve signals for television and radio communications. A typical receiver dish, shown below, can be used for a range of waves in the electromagnetic spectrum.



https://satsklep.pl/en_US/p/Sat-Antenna-85cm-8085HDG-Emme-Esse-dark-grey/6347

The receiver dish can be modelled using a concave mirror and light rays. Although a satellite dish is not truly concave, a teacher decides to model the image formation using a concave mirror.

(a) Complete the ray diagram to show how parallel rays are reflected in concave mirrors in general.



If you need to redraw your ray diagram, use the diagram on page 9.

(b) The students realise that, in order to use the mirror for the model, they will need to know its focal length. They place a 3 cm high Lego toy 30 cm in front of the mirror and determine its image to be 2 cm high.

By first determining the distance of the image from the mirror, calculate the focal length.

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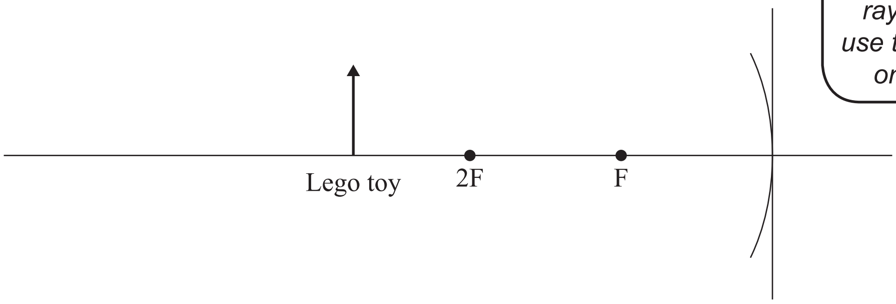
(c) (i) Draw two rays from the Lego toy (object) to locate the position of the image.

Draw and label the image.

If you need to redraw your ray diagram, use the diagram on page 9.

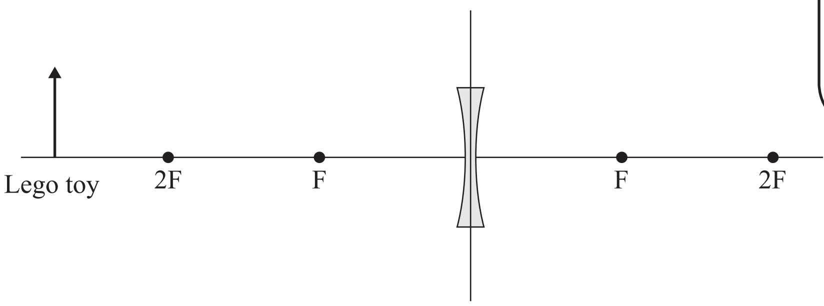


(ii) What would be the effect on the position of the image of increasing the radius of curvature of the mirror?

Explain your answer.

(d) The students replace the mirror with a concave lens. They place a Lego toy in front of the lens, as below.

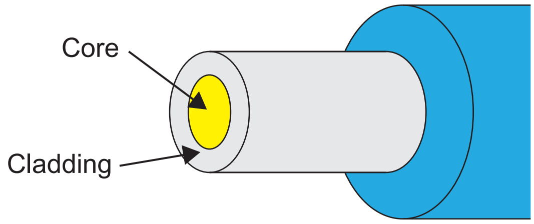
If you need to redraw your ray diagram, use the diagram on page 9.



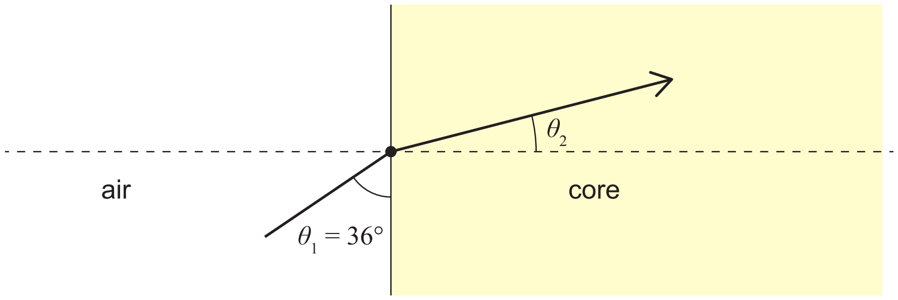
Complete the ray diagram to show the image produced, and describe the nature of the image formed.

QUESTION TWO: FIBRE OPTIC CABLES

Fibre optic networks are being installed throughout New Zealand to increase communication effectiveness and efficiency. An optical fibre consists of a core and cladding, as shown below. The initial stage requires a beam of infra-red waves to be sent into the fibre optic cable so it can be transmitted along great distances.



The diagram below shows infra-red waves travelling from the air into the core:



Refractive index of air = 1.00
Refractive index of the core = 1.45

(a) Calculate the angle θ_2 if angle θ_1 is 36°.

(b) Name and explain the physics phenomenon that occurs at the air / core boundary.

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As the beam moves through the optical fibre, it is continually rebounding off the walls of the core, as shown below. For this to occur, the cladding must have a lower refractive index than the core.

(c) Name the phenomenon that allows this process, and give a comprehensive explanation why it is important that the cladding has a lower refractive index than the core.

(d) The infra-red waves have a frequency of 3.53×10^{14} Hz.
The speed of light in air = 3.00×10^{8} m s $^{-1}$
The refractive index of the core = 1.45

By first determining the wavelength of the incident ray in air, calculate the wavelength of the ray once it has entered the core.

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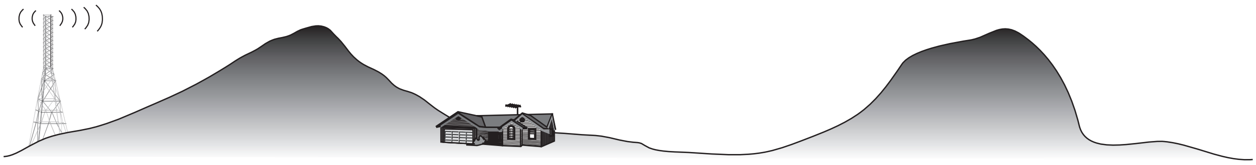
QUESTION THREE: RADIO BROADCASTS

Mountainous regions make radio communication and signal reception particularly difficult. As a result, transmitters need to be strategically placed, and use the correct frequency to ensure the signal is received.

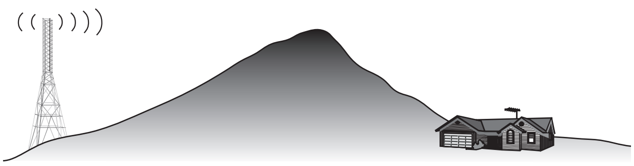
The transmitter shown below is set to broadcast throughout the region. Fred lives in a house between the two hills shown. He enjoys listening to old-fashioned FM radio stations.



(a) If a radio transmitter uses a frequency of 95 MHz, show that the time period for the waves is 10.5 ns.

(b) Describe the phenomenon that allows the transmission to be received at Fred's home despite the transmission tower being out of sight of his house.

Include a diagram in your discussion and explain whether or not longer wavelengths would make reception of signals better for his house shown.



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

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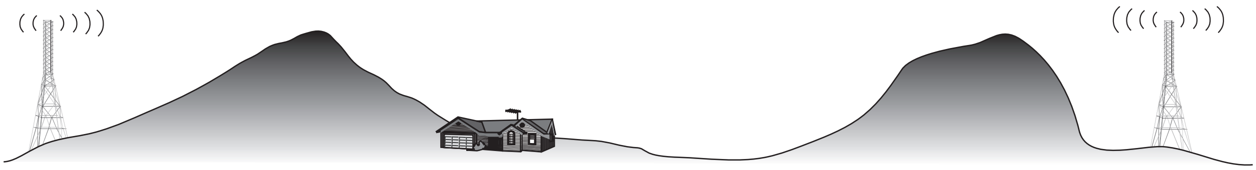
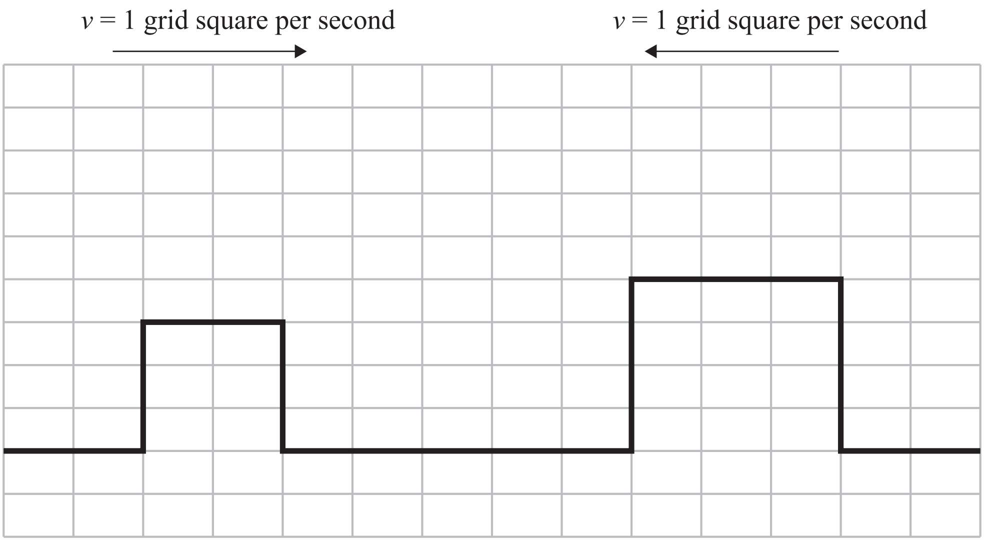
A second transmitter broadcasting on the same frequency is built next to the opposite mountain to boost the signal.

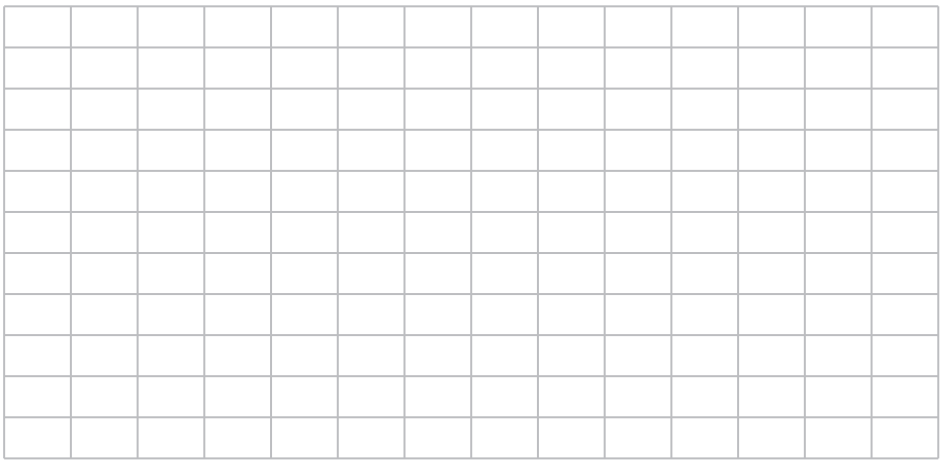


A test pulse is sent from each tower.



(c) Draw the resulting superposition after 3 seconds.

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



Question Three continues on the following page.

(d) When a second transmitter, transmitting at the same frequency, is added, explain with reference to wave interference, why some locations in the valley **may** receive a boosted signal, while other locations **may not**.

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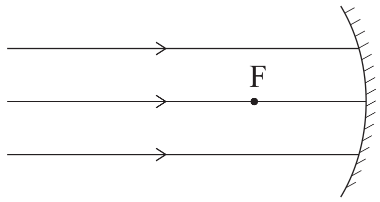
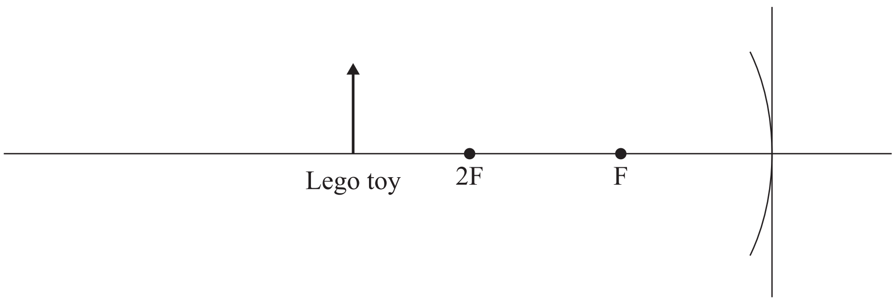
SPARE DIAGRAMS

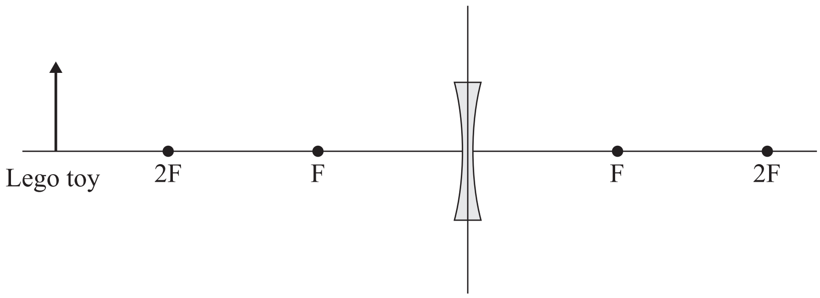
If you need to redraw your ray diagram for Question One (a), use the diagram below. Make sure it is clear which diagram you want marked.



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



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



There are more spare diagrams on the following page.

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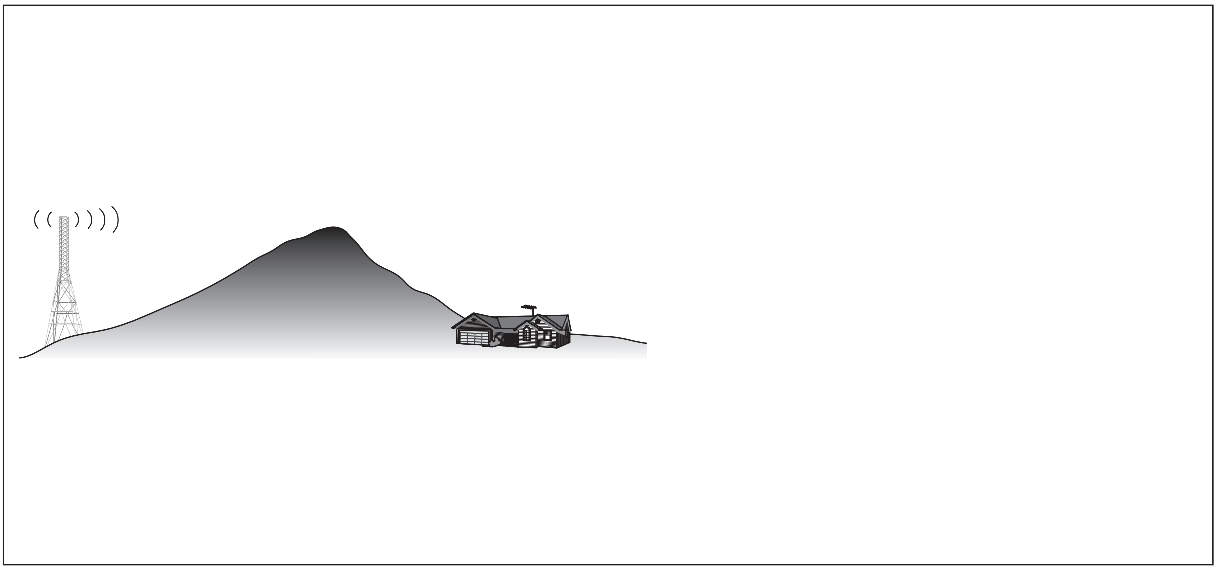
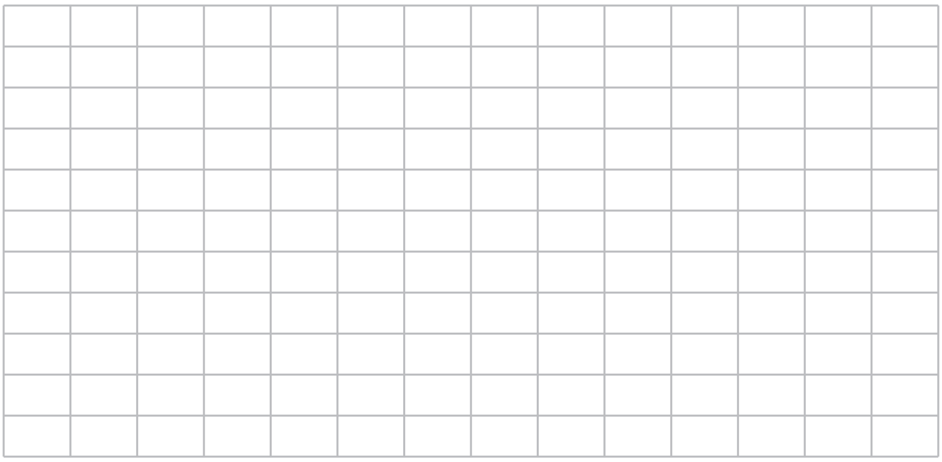
If you need to redraw your diagram for Question Three (b), use the diagram below. Make sure it is clear which diagram you want marked.



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



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

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