91170

911700

2

SUPERVISOR'S USE ONLY

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 2 Physics, 2014

91170 Demonstrate understanding of waves

2.00 pm Tuesday 18 November 2014
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 2–10 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.

Excellence

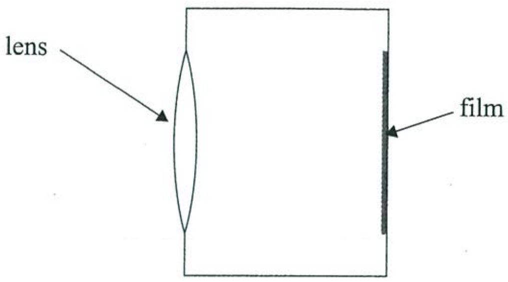
TOTAL 24

ASSESSOR'S USE ONLY

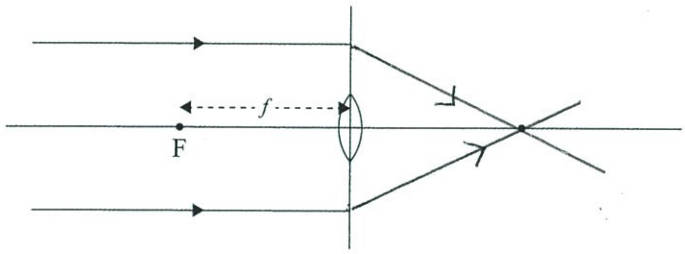
QUESTION ONE: THE CAMERA

ASSESSOR'S USE ONLY

Moana is on holiday at the beach and has a disposable underwater camera. The camera is like a box with a lens at the front and a film at the back, as shown in the diagram below.



(a) Complete the diagram below showing what happens to the two light rays.



If you need to redraw this, use the diagram on page 8.

Correct rays (directions)

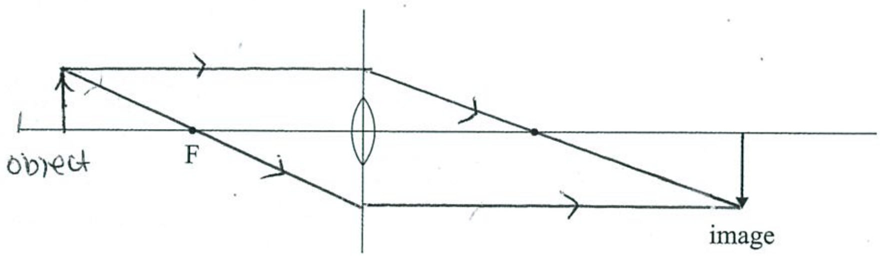
a

91170

(b) The diagram below shows the **image** formed on the film when Moana takes a picture.

Draw two rays to locate the position of the **object**.

State the **nature** of the image (real OR virtual).

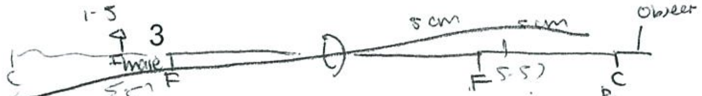


If you need to redraw this, use the diagram on page 8.

Nature of image: real

m

Correct rays (directions), nature



Rebotan Haas

ASSESSOR'S USE ONLY

(c) Moana takes another picture. The image is 1.5 cm high and 5.5 cm from the lens. The focal length of the lens is 5.0 cm.

Calculate the height of the object that she is taking a picture of.

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

$\frac{1}{5} = \frac{1}{5.5} + \frac{1}{d_o}$ ✓

$d_o = 55$ cm ✓

$\frac{h_i}{h_o} = \frac{d_i}{d_o}$

~~1.5 / 58~~

$\frac{1.5}{h_o} = \frac{5.5}{55}$

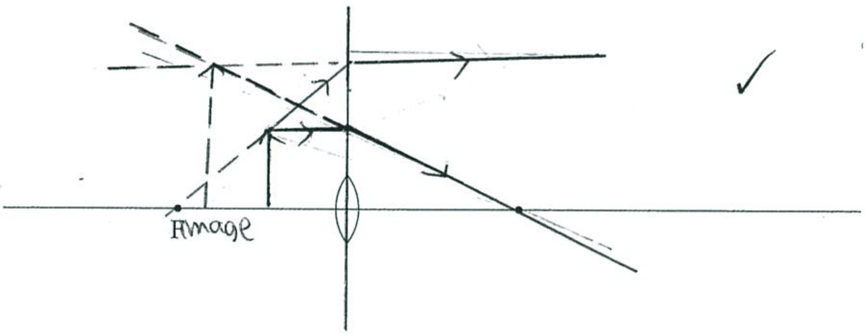
$h_o = 15$ cm ✓

e

Correct formulae, substitution and mathematical calculation

(d) Explain why Moana cannot take a picture of any object closer than 5.0 cm.

Use the diagram below to explain your answer.



✓

focal length is 5.0 cm. If she takes a picture of an object closer than 5 cm, object is between lens and focal point. Thus, upon refraction, the light ray diverges ✓, and does not meet on the other side of the lens where film is. When extended, it produces an enlarged, upright image on the same side of the lens, but this is a virtual image ✓, thus as it is not real, it can not be projected onto a screen thus the image can not be formed on the film.

Hence, Moana can not take a picture of an object closer than 5 cm, which is her film's focal length as this will produce a virtual image on the same side of the lens, thus no image formed on the film. ✓

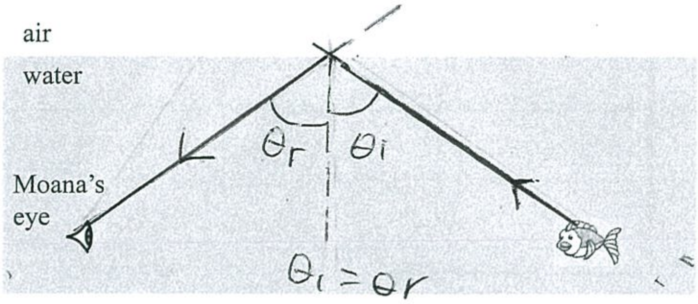
e

Correct diagram AND full explanation as to why no picture can be taken.

E8

QUESTION TWO: AT THE BEACH

Moana is swimming under the water. She can see a fish, and she can also see an image of the fish caused by light reflecting at the water/air interface.



Correct ray (direction)

If you need to redraw this, use the diagram on page 8.

a

(a) State the full name of the process by which Moana can see the image of the fish reflecting at the water/air interface.

Draw one ray on the above diagram to show this process.

Total internal reflection

Correct reason

a

(b) The critical angle at the water/air interface is 47°. The refractive index of air is 1.0.

$\theta_c = 47°$, $\theta_r = 90°$

Calculate the refractive index of the water.

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

$n_1 \times \sin 47° = 1 \times \sin 90$

$n_1 = \frac{1 \times \sin 90}{\sin 47°} = \frac{1}{\sin 47°}$

$n_1 \approx 1.367$

≈ 1.4

$n_1 = 1$ $n_2 = 1.3673....$

Correct formula, substitution + calculation

m

(c) A beam of red light passes from the air into the water.

air 1
water 2

Calculate the **wavelength** and the **frequency** of the light beam as it travels through the water.

The speed of light in air is 3.0×10^8 m s^{-1}. v_1

The wavelength of red light in air is 6.5×10^{-7} m. λ_1

$\frac{n_1}{n_2} = \frac{v_2}{v_1}$

$\frac{1}{1.3673} = \frac{v_2}{3 \times 10^8}$

$v_2 \approx 2.2 \times 10^8$

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

$\frac{1}{1.3673} = \frac{\lambda_2}{6.5 \times 10^{-7}}$

$\lambda_2 = 4.8 \times 10^{-7}$

$f = \frac{v_2}{\lambda_2} = \frac{2.2 \times 10^8}{4.8 \times 10^{-7}}$

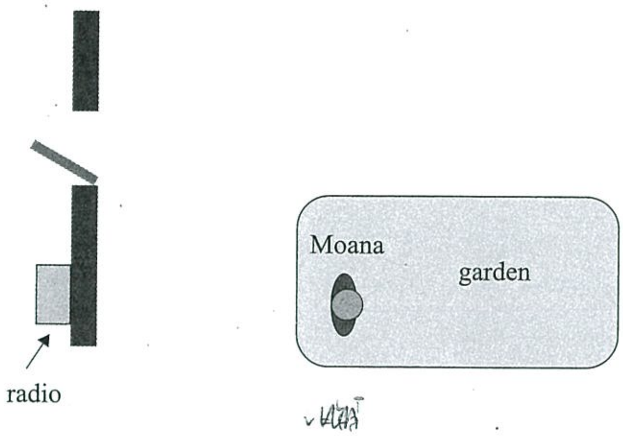
$\approx$ ~~4.58~~ 4.6×10^{14}

Correct calculations for λ and f.

m

ASSESSOR'S USE ONLY

(d) Moana is in her garden, which is just outside her room. There is a radio playing in her room and the door of her room is open.



By comparing the wavelengths of light and sound waves, discuss why Moana can hear, but not see, the radio.

sound waves has a longer wavelengths than light waves, which have shorter wavelengths. Waves with longer wavelengths diffract greater around barrier / through gaps than waves with shorter wavelengths. Thus, sound waves ~~long~~ (from moana's radio), can diffract around (bend around) the gap (her open room door), greater ~~better~~ than light waves. light waves do not diffract as much around the gap from her open room door, as the gap size is much bigger than the wavelength of the wave.

Thus, moana can hear the radio but not see it. //

e

Correct discussion and links made (related to open door).

E8

QUESTION THREE: WATCHING THE WAVES

ASSESSOR'S USE ONLY

(a) Moana is watching water waves coming into the beach. She estimates the wave speed to be 0.50 m s^{-1} and the wavelength to be 1.2 m.

v λ

Calculate the frequency of the waves.

Give your answer with the correct unit and correct number of significant figures.

$f = \frac{v}{\lambda} = \frac{0.50}{1.2}$

$f \approx 0.42$ Hz ✓

Correct calculation AND units and sig. figs.

a

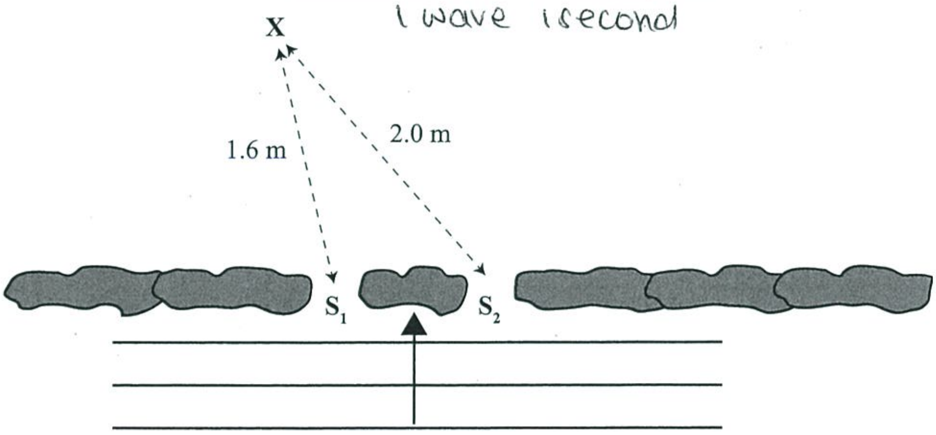
a

(b) At another place there are two gaps (labelled S_1 and S_2) in the line of rocks. There is a set of waves passing through the gaps, creating an interference pattern.

The difference between the distances from S_1 to X and S_2 to X is 0.40 m.

The wave speed is 0.80 m s^{-1} and one wave reaches the wall every second.

1 wave 1 second



Is the point X at a node or an antinode? ~~λ = 1.2~~

Explain your answer.

~~path difference = 0.40 m, wavelength = 1.2 m~~

~~$\frac{1.2}{0.4} = 3$~~

~~Thus pd = nλ where n = 3~~

~~pd = 3 × 0.4 =~~

$f = 1$ Hz, $v = 0.80$ ms^{-1}

$\lambda = \frac{v}{f} = \frac{0.80\text{m}}{1\text{s}} = 0.80$ m ✓

Path difference = 0.40 m, ✓ $\lambda = 0.80$ m

→ continued at the back.

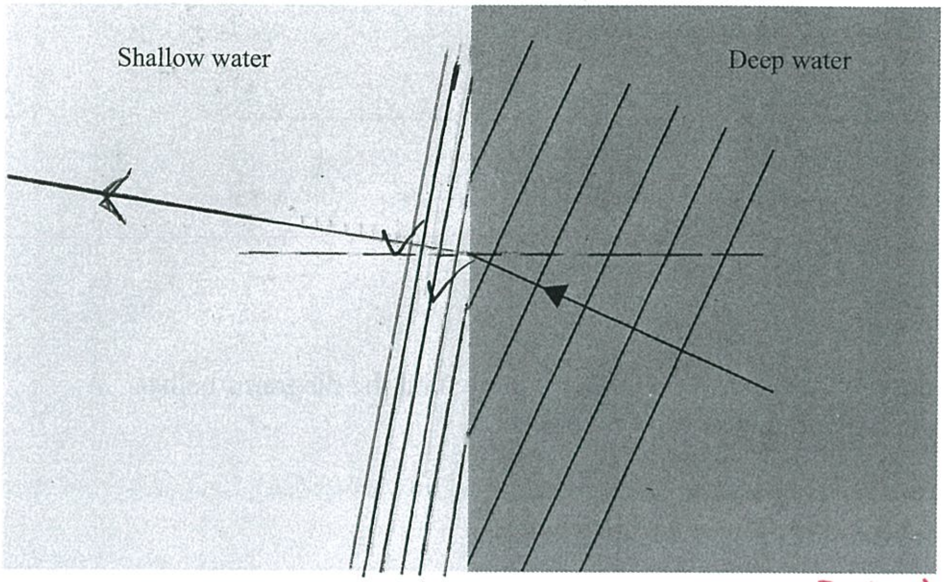
e

wavelength, λ, path difference and relationship to node ALL correct. (See extra sheet)

ASSESSOR'S USE ONLY

(c) Moana watches the waves travel from deep to shallow water. In shallow water, the waves travel more slowly, compared to in deep water.

Complete the diagram showing the **wavefronts** and the **wave direction** in the shallow water.



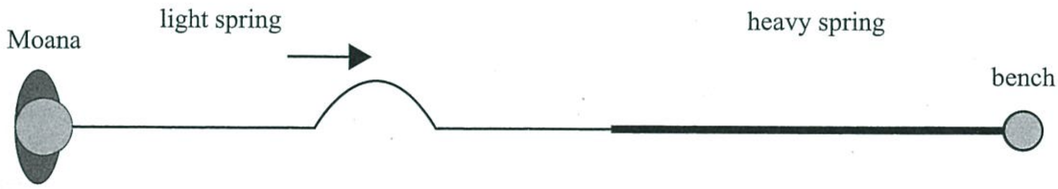
If you need to redraw this, use the diagram on page 9.

m

Both λ and direction

(d) At school, Moana investigates waves in springs. She connects a light spring to a heavy spring, and ties the heavy spring to the leg of a bench. Moana sends a single pulse along the light spring, as shown in the diagram below.

(Waves travel faster in a light spring than in a heavy spring.)



The diagram below shows the pulse after it has moved into the heavy spring.

mark this one please ☺

On the same diagram, draw the pulse reflected in the light spring showing:

- the **phase** of the pulse
- the **distance travelled** ~~by~~ by the pulse.

Give reasons for your answer.

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

There is a phase change, thus it is inverted. The distance travelled by the pulse in light spring will be greater (reflected pulse) than the distance travelled by pulse in heavy spring (transmitted pulse), as wave travel faster on light spring than in heavy spring. This is a fixed end reflection. (The amplitude of ~~both~~ each of the ~~reflected~~ pulses ~~are~~ is smaller than original amplitude)

m

E8

Diagram AND

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

QUESTION NUMBER | ASSESSOR'S USE ONLY

3b $\frac{pd}{\lambda} = \frac{0.40}{0.80} = 0.5$.

creacing ~~Destructive~~ $pd = \frac{1}{2}\lambda = \frac{1}{2} \times 0.8 = 0.4$ ✓
~~ordering~~
Thus $pd = (n - \frac{1}{2})\lambda$ where $n = 1$
$pd = (1 - \frac{1}{2}) \times 0.80 = 0.4$

Thus, point x is on a node, ✓ where destructive ✓ ~~destructive~~ interference occurs (i.e crest meets trough). When waves half a wavelength apart interfere, ~~(pd = $\frac{1}{2}\lambda$ = 0.4 or pd = (1-$\frac{1}{2}$)×0.80 = 0.4)~~ they interfere destructively, cancel out to produce no displacement, thus wave will be calm. Thus point x is at a nodal line (at a node) // Seen