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90182

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

# Level 1 Physics, 2003

## 90182 Demonstrate understanding of reflection and refraction of waves and light

Credits: Five
9.30 am Thursday 20 November 2003

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 answer ALL the questions in this booklet.

For all numerical answers, full working must be shown. The answer should be given with an SI unit.

For all 'describe' or 'explain' questions, the answer should be in complete sentences.

**Formulae you may find useful are given on page 2.**

If you need more space for any answer, use the pages 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.**

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| Achievement Criteria | | |
|---|---|---|
| **Achievement** | **Achievement with Merit** | **Achievement with Excellence** |
| Recall or describe phenomena, concepts or principles. | Describe or explain how phenomena, concepts, principles or relationships are interrelated. | Explain or analyse phenomena in terms of concepts, principles or relationships. |
| Solve problems with direction. | Solve problems by selection. | Solve problems requiring more than one step or the synthesis of information. |
| **Overall Level of Performance (all criteria within a column are met)** | | |

You are advised to spend 50 minutes answering the questions in this booklet.

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You may find the following formulae useful.

$$v = \frac{d}{t} \qquad v = f\lambda \qquad f = \frac{1}{T}$$

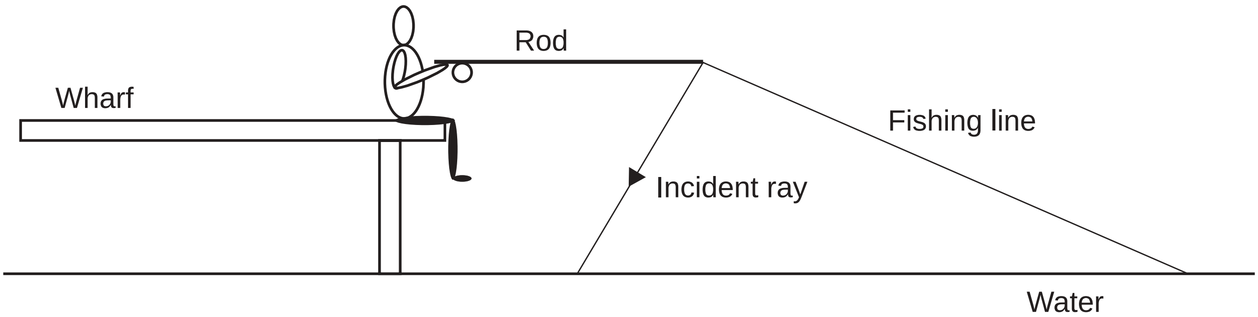
$$\text{angle } i = \text{angle } r \qquad d_i = d_o \qquad H_i = H_o$$

$$\frac{\sin\theta_{air}}{\sin\theta_{medium}} = n_{medium}$$

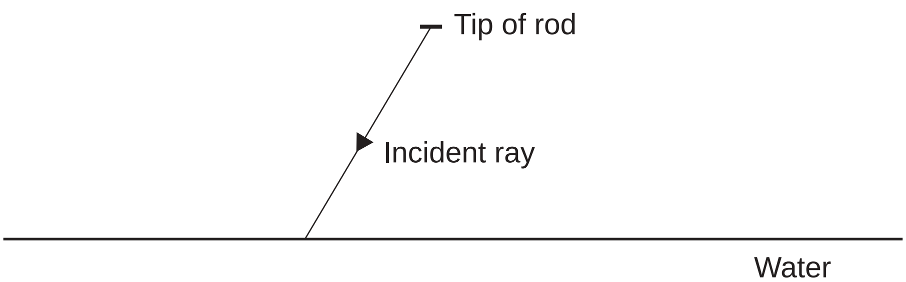
## QUESTION ONE: Reflection and Refraction of Light

Jimmy was sitting on the wharf, fishing early in the morning. The water was very still and clear.

(a) He looked at the water and could see a reflection of his fishing rod. The diagram below shows Jimmy sitting on the wharf with his fishing rod. An incident light ray going from the tip of the rod to the water is shown.



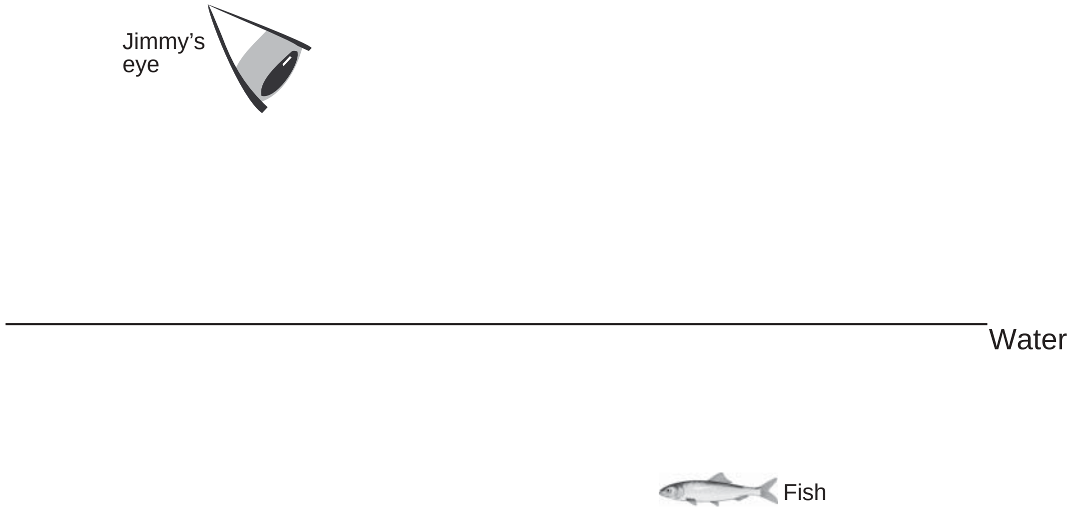

(i) Draw the reflected ray on the diagram below.



(ii) On the diagram in (a) (i), label the angle of reflection with the letter 'r'.

(iii) On the same diagram, draw another incident ray from the tip of the rod to a **different** point on the water. Then use **both** rays to show the position of the image of the tip of the rod. Label the image with the letter 'I'.

(b) Jimmy sees a fish swimming below the water's surface. The diagram below shows where the fish is, but this is not where Jimmy sees it. The diagram also shows the position of Jimmy's eye.




(i) On the diagram above, draw rays to show where Jimmy sees the image of the fish. Your diagram requires **two** rays to be drawn from the **same** point on the fish. Your diagram needs to show how these two rays enter Jimmy's eye.

(ii) State why the image of the fish is **virtual**.

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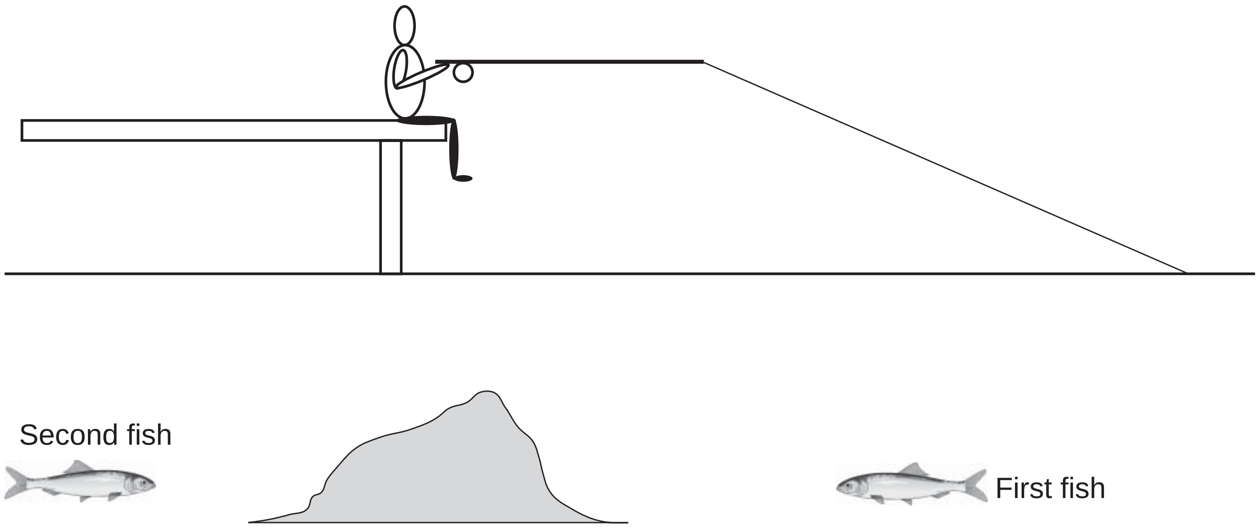
(c) A second fish is swimming towards the first fish. The second fish **can see** the first fish, even though there is a very large rock obscuring its direct view.




(i) State the name of the physical phenomenon that allows the second fish to see the first fish.

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(ii) Discuss the conditions necessary for this phenomenon to occur **in this situation**.

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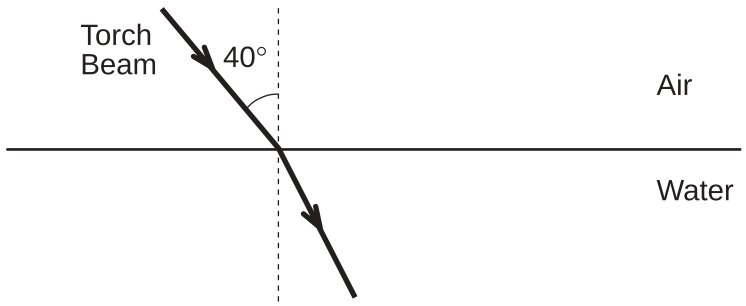
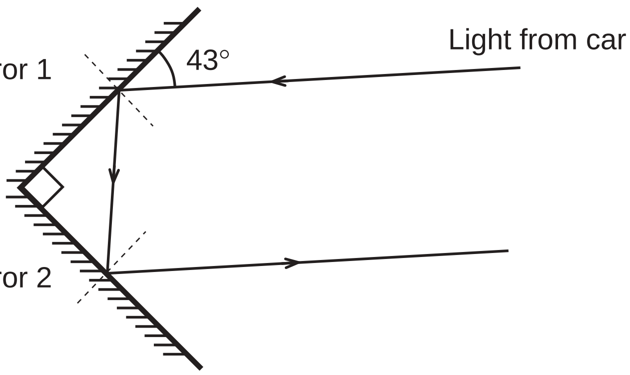
(d) At night, Jimmy is out on the wharf playing with a powerful spotlight torch. He shines the torch into the water as shown in the diagram below. (Note that the diagram is not to scale.) Calculate the angle of refraction of the torch beam in the water given that the refractive index of water ($n_{water}$) is 1.33 and the angle of incidence is 40°.




Angle of refraction = ______________

(e) Jimmy rides his bike home that night. On the back of his bike there is a reflector that gives a bright red reflection when car headlights shine on it. The reflector is made up of many small prisms. Because of total internal reflection, each of these prisms acts like two reflecting surfaces (mirrors) at right angles. The diagram below shows how one ray of light is reflected.




(i) Calculate the angle of incidence at mirror 1.

Angle of incidence at mirror 1 = ______________

(ii) Calculate the angle of incidence at mirror 2.

Angle of incidence at mirror 2 = ______________

Reflectors are constructed in the way explained in (e) to allow car drivers to see the bright red reflection.

(iii) Explain **why** reflectors are constructed with **right-angled** reflecting surfaces.
(To answer this question you may like to consider what would happen if a bike reflector were a **simple**, **vertical** reflecting surface.)

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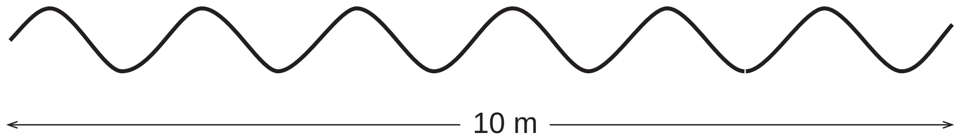
## QUESTION TWO: Waves

(a) Jimmy returns to the wharf the next day. A speedboat goes past the wharf, causing waves. Jimmy counts six waves coming in and hitting the wharf in 20 seconds. They are shown on the diagram below.




(i) Show that the period of the waves is 3.3 seconds.

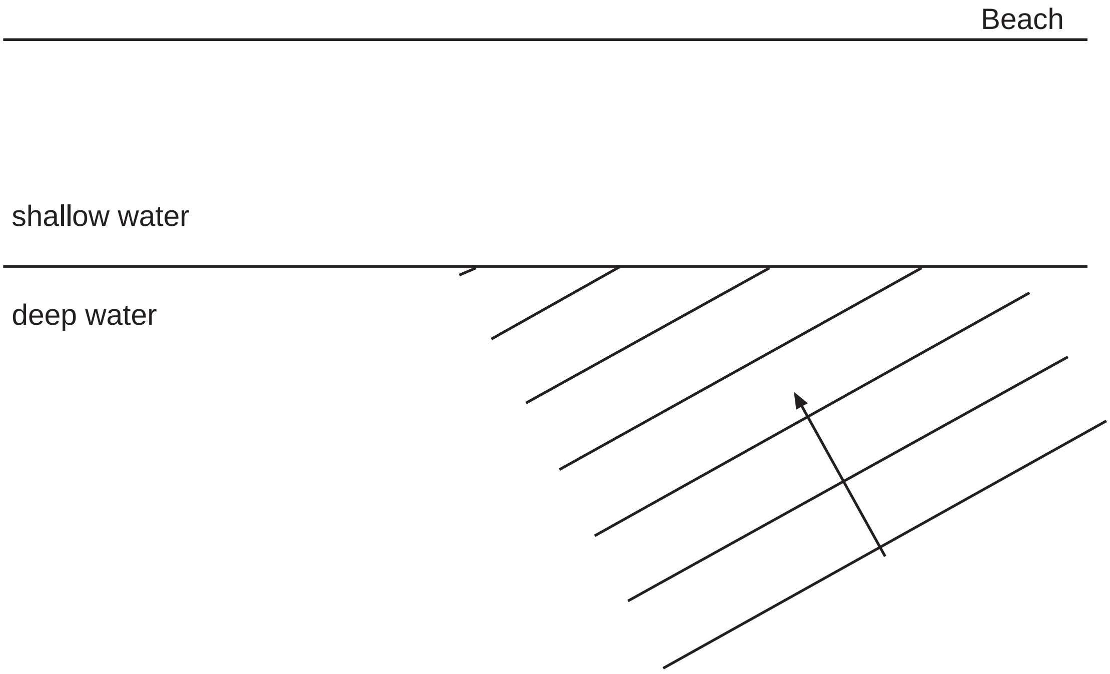
(ii) Calculate the frequency of the waves.

Frequency = ______________ Hz

(iii) Calculate the velocity of the waves.

Velocity = ______________ $m\ s^{-1}$

(b) An aerial view of more waves is shown below. These waves have gone past the wharf and are heading towards the beach where the depth of the water suddenly becomes **shallower**.




(i) Describe what happens to the **speed** of the waves as they go into shallower water.

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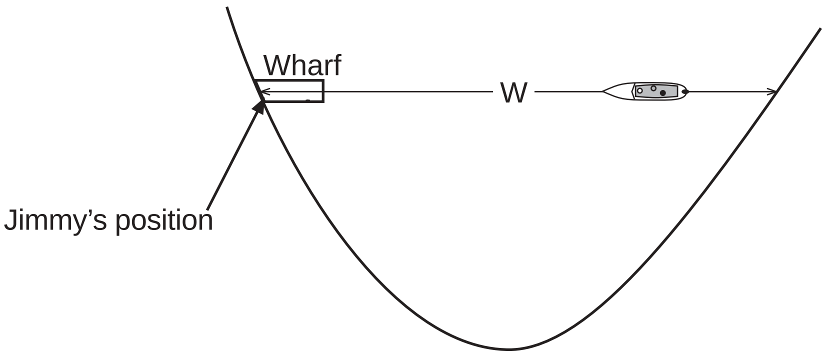
(ii) Complete the diagram above to show how the wavecrests are refracted as they approach the beach.

(c) Some of Jimmy's friends are in the speedboat. When the speedboat is **three-quarters (0.75)** of the way across the bay, his friends call out across the water to him. Jimmy hears their voices and 0.50 seconds later he hears an echo of their voices. The speed of sound in air is 330 m $s^{-1}$.

Calculate the width of the bay (labelled W) on the diagram.




Width of bay = ______________ m

(d) Jimmy switches on the radio and tunes it to 91FM (frequency $91 \times 10^6$ Hz). Radio waves travel at the speed of light (300 000 km $s^{-1}$) and are transverse.

(i) Convert 300 000 km $s^{-1}$ into m $s^{-1}$.

(ii) Calculate the wavelength of the radio waves to which Jimmy tuned the radio.

Wavelength = ______________ m

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(e) The sound waves from the radio speaker are longitudinal. Explain how longitudinal waves are **different** from transverse waves.

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**Extra paper for continuation of answers if required.**
**Clearly number the question.**

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Question Number

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