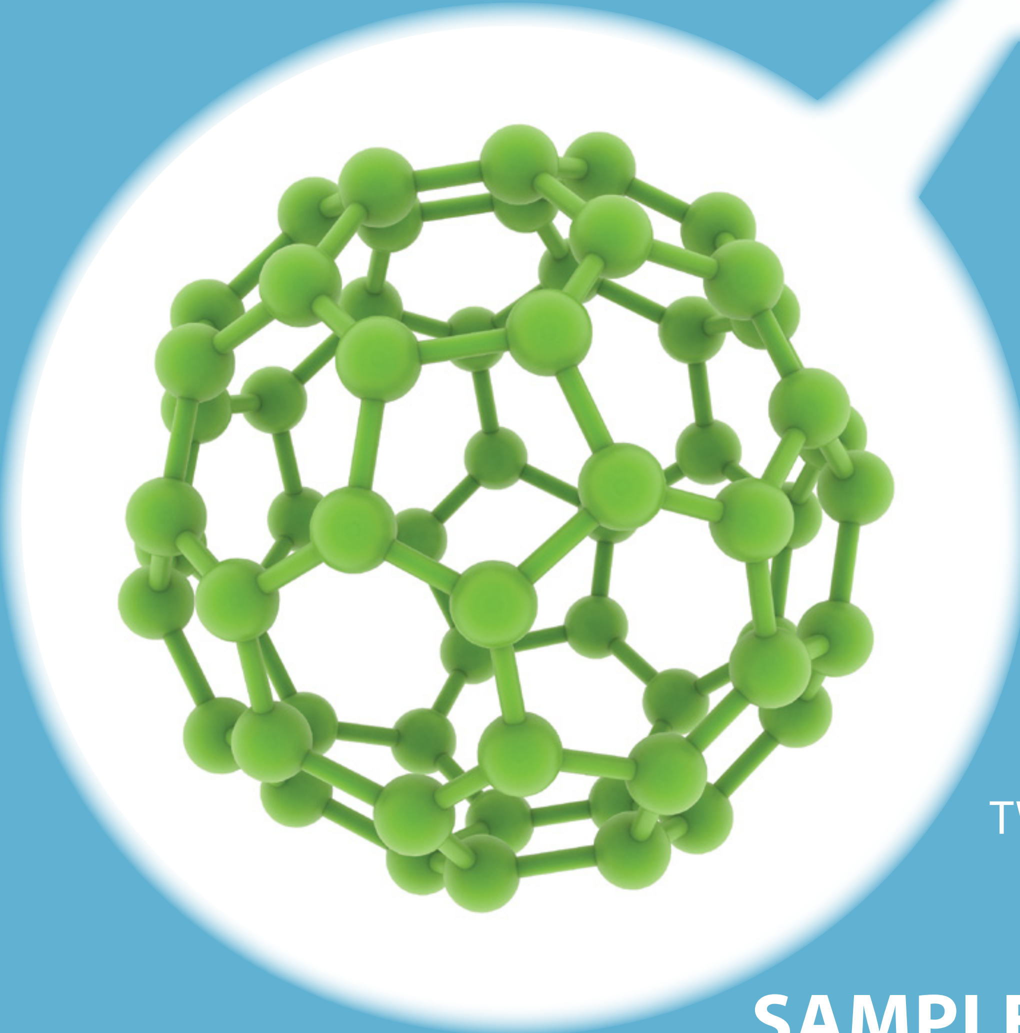


OCR
RECOGNISING ACHIEVEMENT

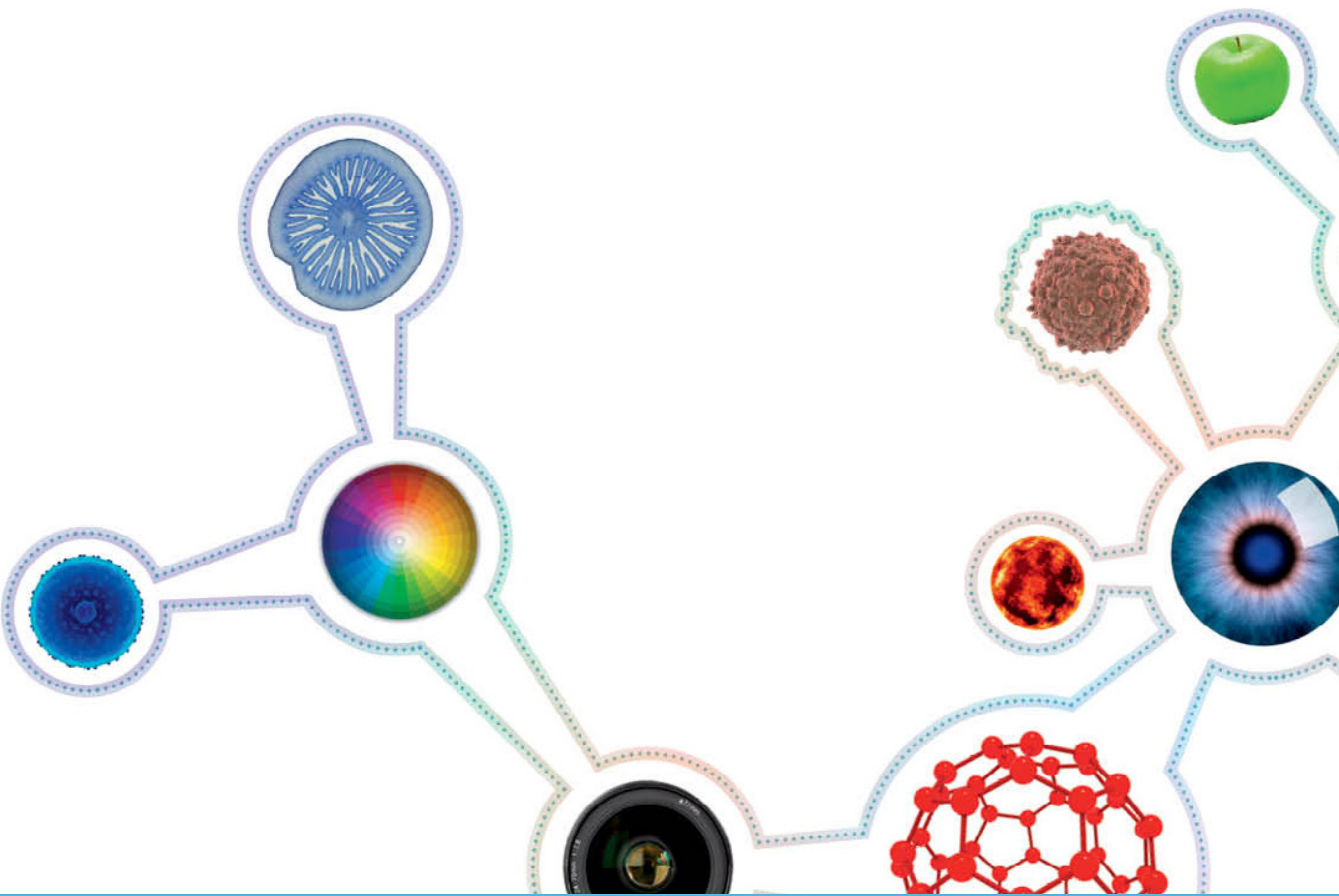
TWENTY FIRST CENTURY
SCIENCE SUITE

UNIT A184 : SAMPLE CANDIDATE WORK AND MARKING COMMENTARIES

VERSION 1 MAY 2012

www.ocr.org.uk/science

INDEX



INTRODUCTION

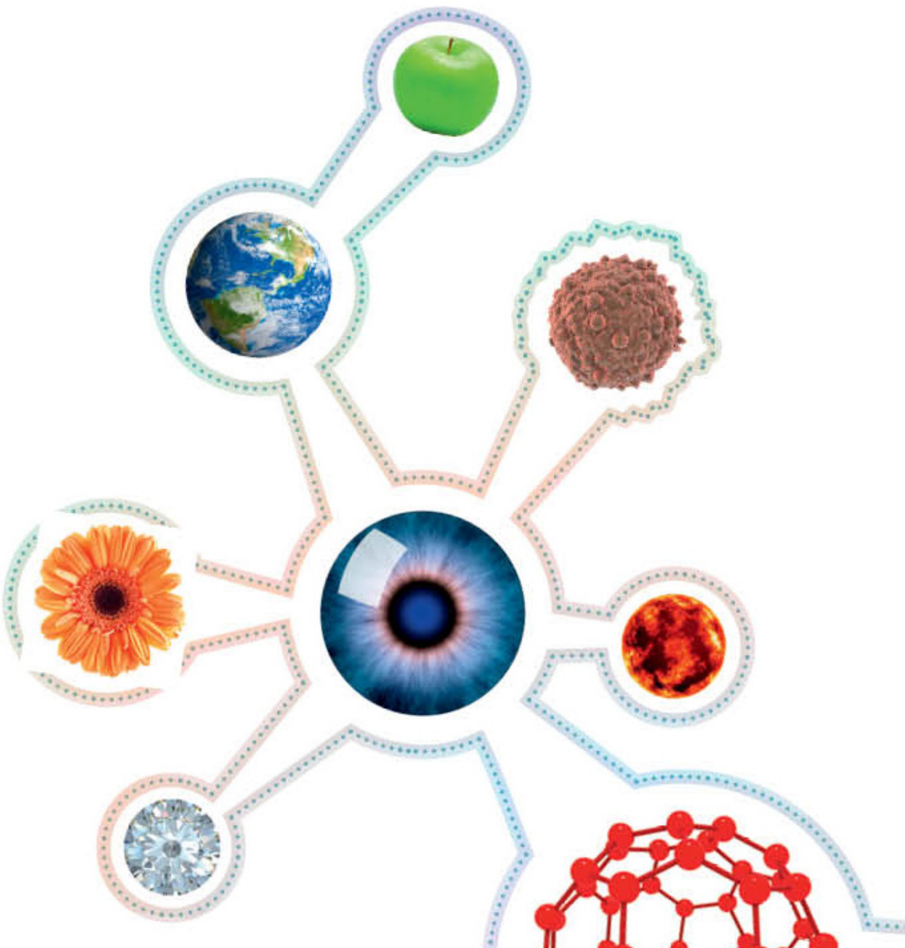
These support materials are intended to support teachers in their marking. There is a candidate style response with accompanying commentary. These exemplars are based on the published Specimen Assessment Materials (SAMs), which can be downloaded from the relevant OCR webpage for the specification.

The exemplars and commentaries should be read alongside the Specifications and the Guide to Controlled Assessment for GCSE Twenty First Century Science, all of which are available from the website.

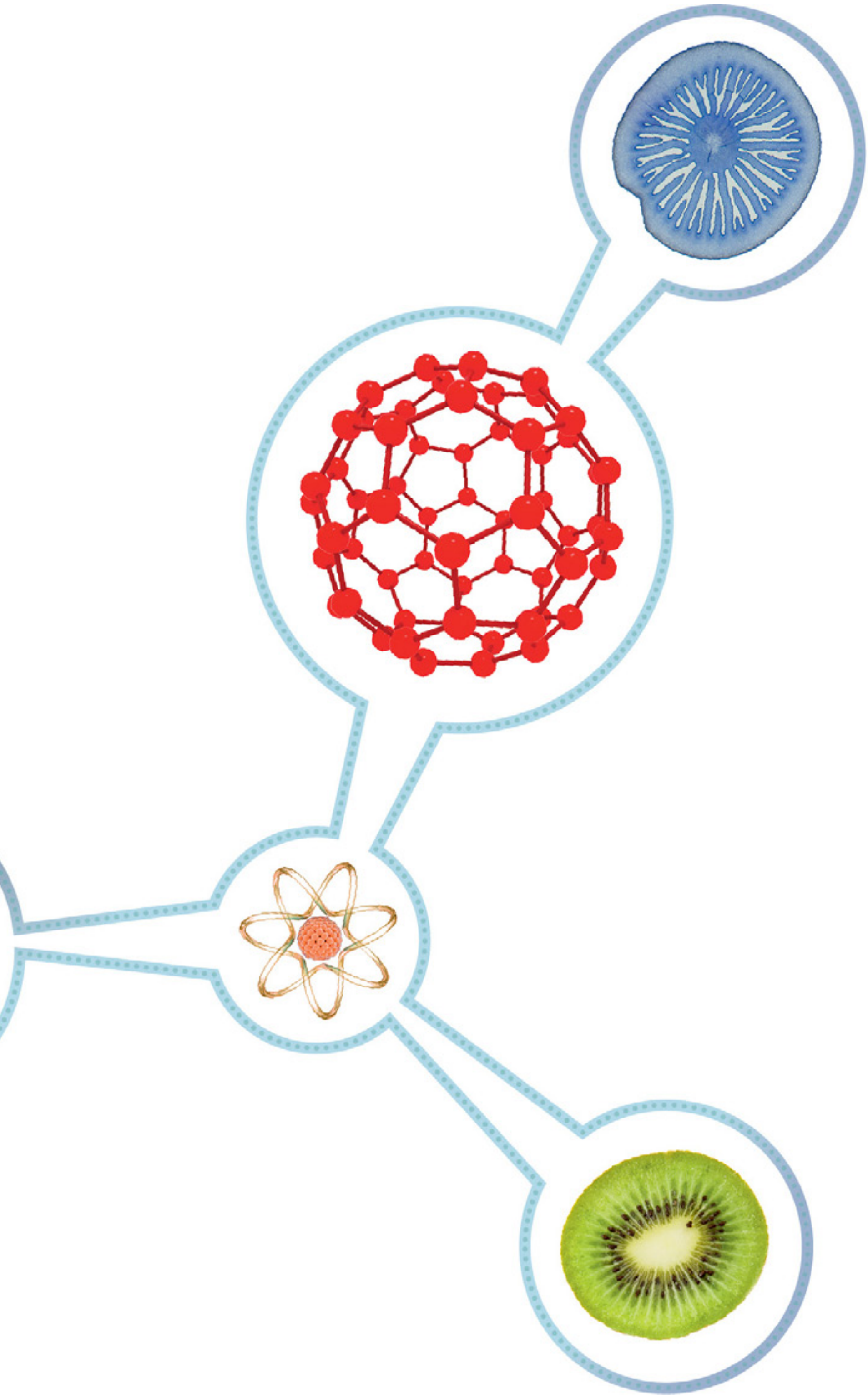
OCR will update these materials as appropriate.

Centres may wish to use these support materials in a number of ways:

- teacher training in interpretation of the marking criteria
- departmental standardisation meetings
- exemplars for candidates to review.



INFORMATION FOR TEACHERS



OCR
RECOGNISING ACHIEVEMENT

SPECIMEN

GCSE TWENTY FIRST CENTURY SCIENCE
ADDITIONAL SCIENCE A A154/INST
PHYSICS A A184/INST

Practical Investigation
Factors that affect the speed of a water wave.

CONTROLLED ASSESSMENT
INFORMATION FOR TEACHERS

This assessment will be changed every year. Please check on OCR Interchange that you have the Controlled Assessment material valid for the appropriate assessment session.

- This document is confidential to teachers and must not be released to candidates.
- For details of the level of control required for this assessment refer to Section 5 of the specifications.
- There are two documents provided for candidates for this Controlled Assessment task:
  Information for candidates (1) defines the topic of the investigation and places it into a relevant context. This should be issued to candidates at the start of the task.
  Information for candidates (2) provides some secondary data to supplement that which candidates collect for themselves. It should be issued to candidates only on completion of the data collection part of their investigation.
- The total number of marks for this Controlled Assessment task is **64**.
- Internally assessed marks **must** be submitted by 15 May.
- This Controlled Assessment task is valid for submission in the June examination series only.
- This document consists of **4** pages. Any blank pages are indicated.

Teachers are responsible for ensuring that assessment is carried out against the Controlled Assessment set for the relevant examination series (detailed above).

Assessment evidence produced that does not reflect the relevant examination series will not be accepted.

Turn over

Introduction

This 'Information for teachers' is confidential and must not be released to candidates.

Task title: Factors that affect the speed of a water wave.

Each candidate for Controlled Assessment in the June examination series must present marks for one of the Practical Investigation tasks that is appropriate to the applicable specification. All internally assessed marks must be submitted by 15 May.

The marked work of all candidates must be retained by the centre. Some of the work will be required for moderation.

General guidance for teachers

These notes provide background information for the preparation of candidates for these tasks and advice on the assessment of the Practical Investigation report.

Reference should also be made to Section 5 of the specification for Additional Science A or Physics A and to the *Guide for Controlled Assessment for GCSE Twenty First Century Science*.

Task setting is under high control. Tasks are therefore set by OCR. Where appropriate, tasks may be contextualised by individual centres to take account of local circumstances, including availability of resources and the needs of candidates. However, assessments must be based on the published marking criteria (within Section 5 of the specifications). If there is any doubt about whether a contextualised task still sufficiently matches the task and criteria, centres should seek confirmation from OCR that the task is still valid.

Preparation of candidates

It is expected that before candidates attempt a Controlled Assessment task they will have received general preparation in their lessons. Learning activities to develop the relevant skills should have been provided and the broad requirements of the assessment made clear to candidates.

More specific details of practical techniques, the development of skills associated with these techniques, and possible methods and choice of equipment for the task should be covered when teaching the relevant part(s) of the specifications, and must be completed prior to setting the task.

From their work for Module P1: The Earth in the Universe, candidates should be familiar with waves and some of the factors that can affect the speed of a wave.

Assessment of the quality of written communication (QWC)

The quality of written communication is assessed in Strands S and R of this Controlled Assessment task. Candidates should be advised that the quality of their written communication will be assessed. Further information about the assessment of QWC may be found in the specifications.

Risk assessment

It is the centre's responsibility to ensure the safety of all candidates. Teachers are responsible for making their own risk assessment for the task prior to candidates attempting the practical work, and for ensuring that appropriate health and safety procedures are carried out. However, teachers must not provide candidates with a risk assessment since this is included in the marking criteria for Aspect S(b). If candidates require additional guidance on managing safety once the task has started then this will need to be reflected in the marks awarded.

Guidance on assessment

All assessment of the Practical Investigation Controlled Assessment is based on the final report submitted by the candidates.

The marking procedure and marking criteria are described in detail within Section 5 of the specifications. Marking decisions should be recorded on the respective cover sheets (available to download from www.ocr.org.uk and included in the *Guide for Controlled Assessment for GCSE Twenty First Century Science*). Candidates' reports should be annotated to show how marks have been awarded in relation to the marking criteria.

Additional guidance on marking criteria

Detailed guidance on applying the marking criteria will be found in the *Guide for Controlled Assessment for GCSE Twenty First Century Science.*

The following additional brief notes provide some clarification of what may be expected from candidates in some strands. However, all marking decisions must be consistent with the marking criteria.

Strand S

Reference should be made to the appropriate science in Module P1: The Earth in the Universe.

Quality of written communication is assessed in this strand.

Strand R

Reference should be made to the appropriate science in Module P1: The Earth in the Universe.

Quality of written communication is assessed in this strand.

Guidance for technicians and teachers

Task title: Factors that affect the speed of a water wave.

Candidates plan their own investigations and may therefore require access to other apparatus at the discretion of the centre.

Teachers are advised to check that the range of apparatus provided will enable candidates to plan and carry out appropriate experiments to collect valid data.

In general candidates will need a means of generating waves and measuring their speed.

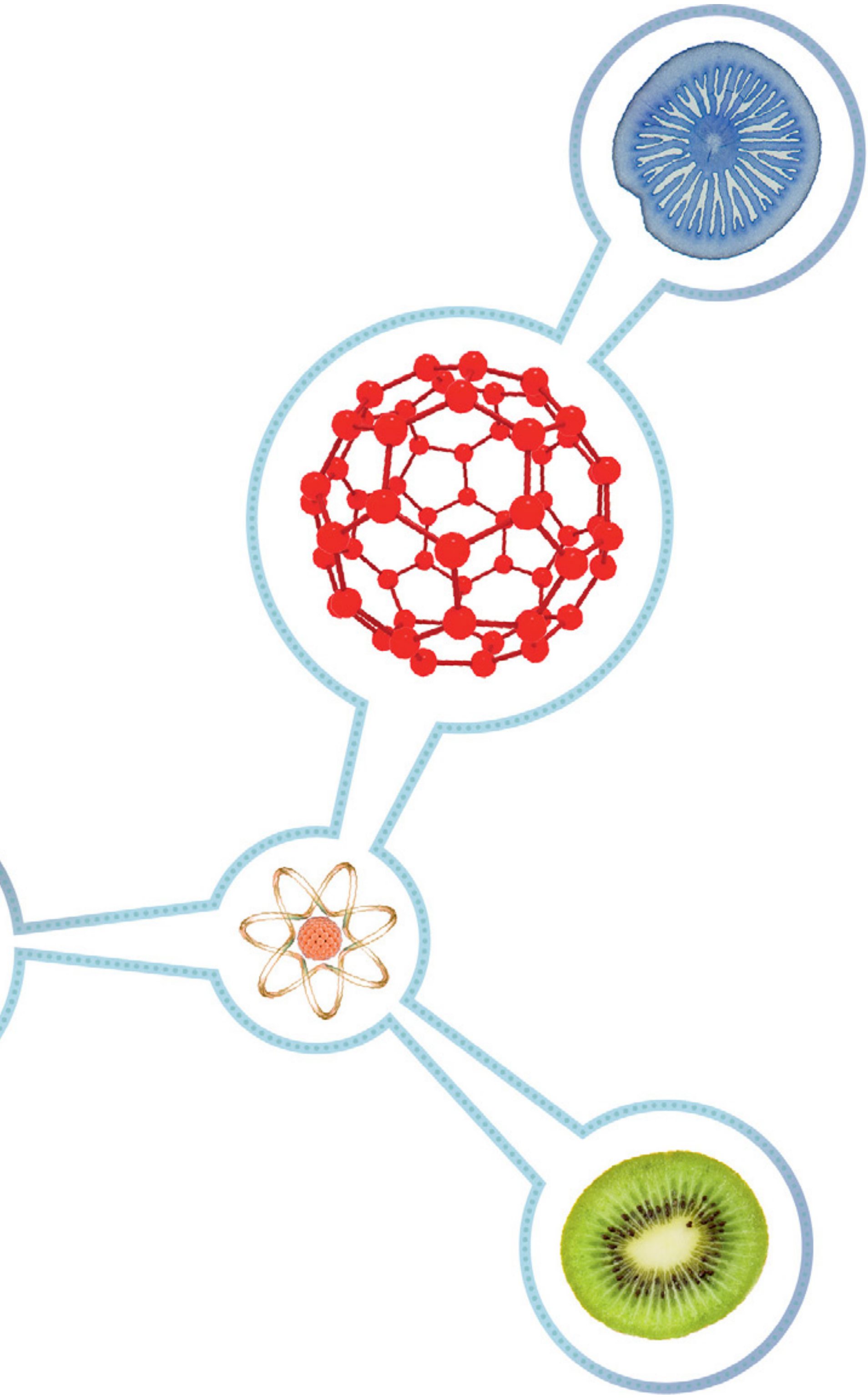
Apparatus suggested

- Ripple tanks
- Stop clocks
- Rulers
- Trays (see note 1)
- Volume measures
- Thermometers
- Signal generators/oscillators

Notes

1. a reasonable wave can be generated by lifting one end of a tray containing water and then dropping the tray.

INFORMATION FOR CANDIDATES



OCR
RECOGNISING ACHIEVEMENT

SPECIMEN

GCSE TWENTY FIRST CENTURY SCIENCE
ADDITIONAL SCIENCE A A154
PHYSICS A A184

Practical Investigation
Factors that affect the speed of a water wave.

CONTROLLED ASSESSMENT
INFORMATION FOR CANDIDATES (1)

This assessment will be changed every year. Please check on OCR Interchange that you have the Controlled Assessment material valid for the appropriate assessment session.

- To be issued to candidates at the start of the task.
- Your quality of written communication will be assessed.
- The total number of marks for this Controlled Assessment task is **64**.
- This Controlled Assessment task is valid for submission in the June examination series only.
- This document consists of **2** pages. Any blank pages are indicated.

Teachers are responsible for ensuring that assessment is carried out against the Controlled Assessment set for the relevant examination series (detailed above).

Assessment evidence produced that does not reflect the relevant examination series will not be accepted.

Released: June 20##
DC (AC/SW) 49106/3

Turn over

Information for candidates

You are going to carry out an investigation into a factor that affects the speed of a water wave.

Background

Water waves range from the ripples in a puddle to tsunami which can be hundreds of meters high. The speed of water waves is important for sailors on boats and ships, for disaster prediction in the case of tsunami and of course for the surfers.

You will choose one factor and investigate this factor's effect on the speed of a water wave

OCR RECOGNISING ACHIEVEMENT

SPECIMEN

GCSE TWENTY FIRST CENTURY SCIENCE
ADDITIONAL SCIENCE A A154
PHYSICS A A184

Practical Investigation
Factors that affect the speed of a water wave.

CONTROLLED ASSESSMENT
INFORMATION FOR CANDIDATES (2)

This assessment will be changed every year. Please check on OCR Interchange that you have the Controlled Assessment material valid for the appropriate assessment session.

- To be issued to candidates **only** on completion of the data collection part of their Practical Investigation.
- Your quality of written communication will be assessed.
- The total number of marks for this Controlled Assessment task is **64**.
- This Controlled Assessment task is valid for submission in the June examination series only.
- This document consists of **3** pages. Any blank pages are indicated.

Teachers are responsible for ensuring that assessment is carried out against the Controlled Assessment set for the relevant examination series (detailed above).

Assessment evidence produced that does not reflect the relevant examination series will not be accepted.

Turn over

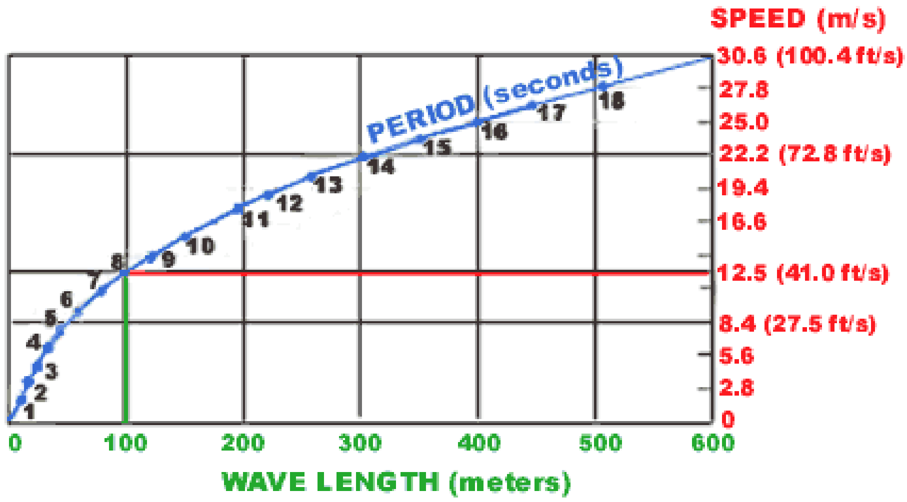
2

These secondary data can be used as part of your Practical Investigation.

You can select the data that is useful for you.

Deep Water waves

There is a relationship between wave period, wave length, and wave speed.



Reference: http://www.bigelow.org/virtual/buoy_sub1.html

Wavelength and frequency of waves in a ripple tank.

Results from a student experiment

frequency in Hz	wavelength in cm
15	2.0
20	1.5
25	1.2
30	1.0
35	0.8
40	0.7
45	0.6
50	0.6

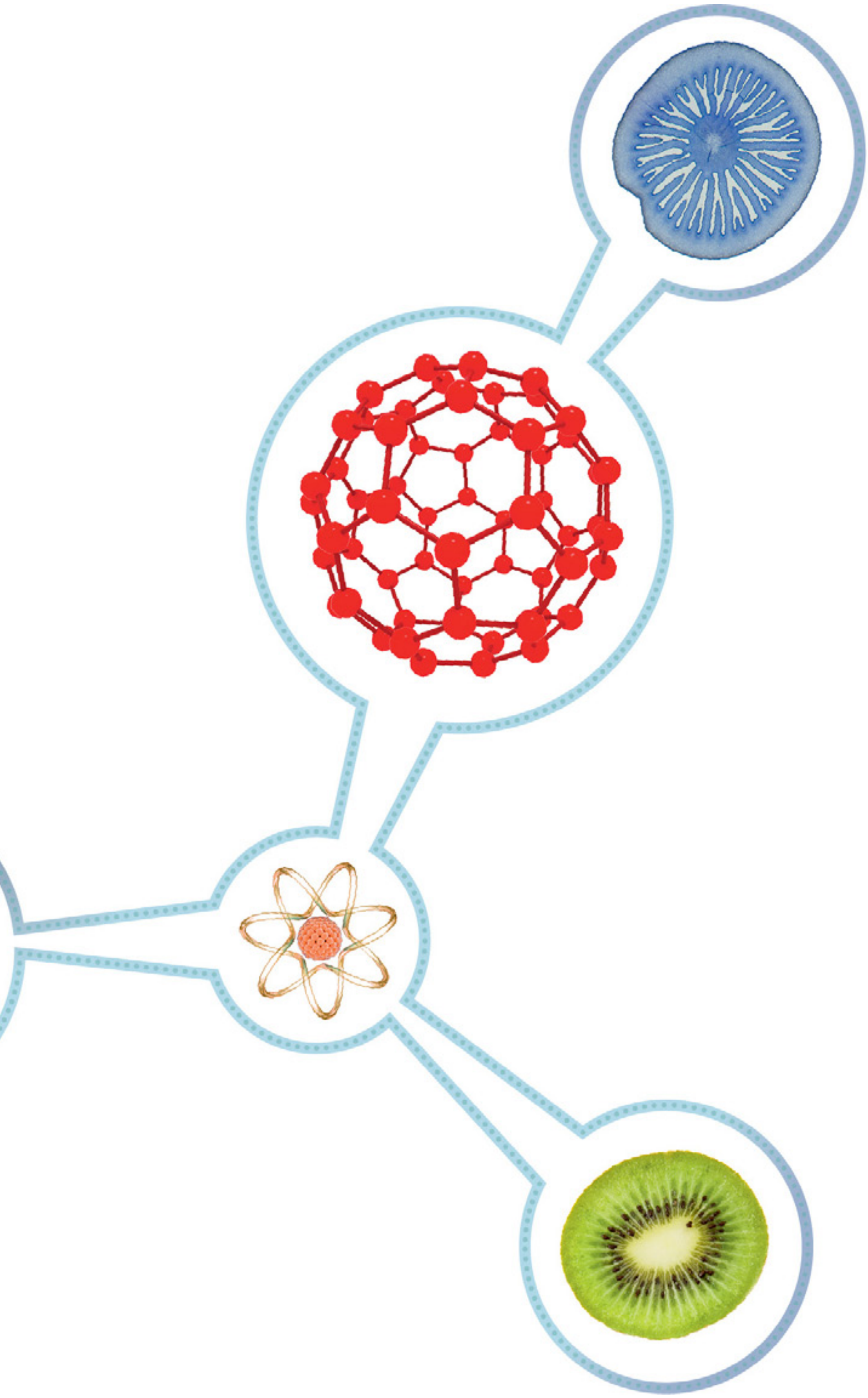
Shallow water gravity waves.
Gravity is the restoring force, which forces the motion to be largely longitudinal and independent of λ.

$$v = \sqrt{gd}$$

Where v is the wave velocity, g is the acceleration due to gravity and d is the depth.
This is the region in which the ripple tank is supposed to operate.

http://www.physics.utoronto.ca/~phy225h/experiments/ripple/RIPPLE.pdf

CANDIDATE SCRIPT AND COMMENTARY

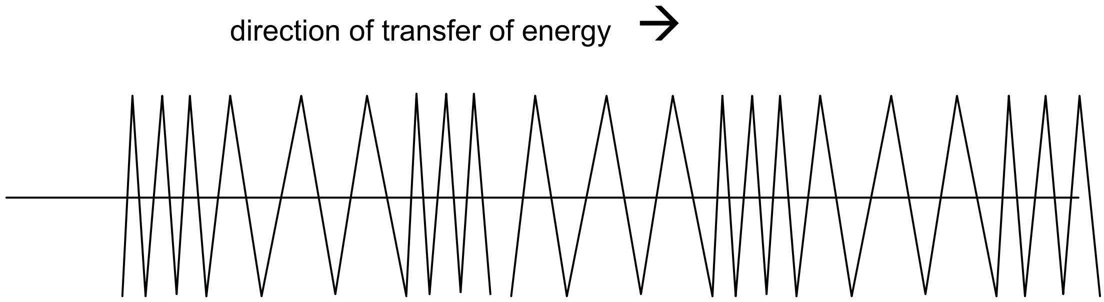


CA Investigation Exemplar 3 - Physics - Waves in Water - Script

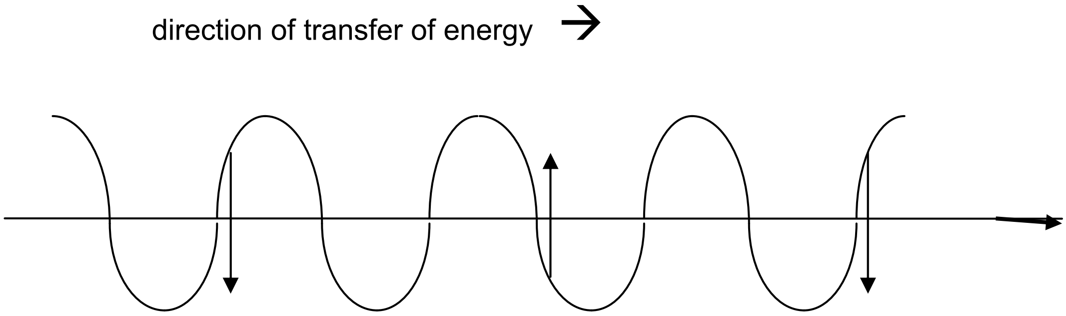
Waves in water

Waves are regular patterns of disturbances which transfer energy in the direction of travel without transferring matter. There are two types of waves, 'longitudinal' and 'transverse'.

In longitudinal waves, the movement is backwards and forwards along the direction of travel of the wave.



In transverse waves, the vibrations (displacements) are at right angles to the direction of travel of the wave –

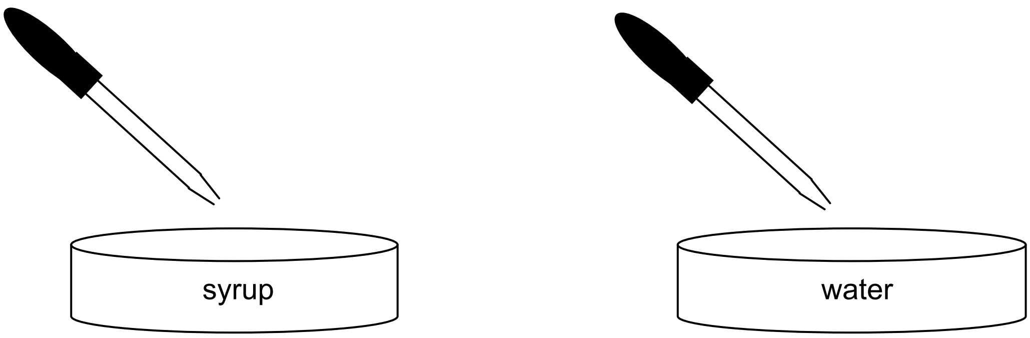


Waves in water are basically transverse waves, but not quite – the water particles move with a circular motion, and are also carried along very slightly in the direction of the wave.

I have been asked to study how fast the waves travel. First, I will consider what factors might affect this.

The type of liquid

Some liquids are thicker than others and this may have an effect. We tested this with some golden syrup.



We put syrup in one dish and water in another, then allowed one drop to fall into each dish. We watched very carefully to see which set of ripples spread across the dish fastest. We found that the waves in the syrup were much slower and died out almost at once. We also tried with mixtures of syrup and water and found that the runnier the liquid, the faster and further the ripples spread.

In most practical situations, it is waves in water that people want to know about, and syrup is messy to work with. We decided that we would work only with water. However, the viscosity of water is affected by changes in temperature, so we always used distilled water and we checked the temperature each day.

We had been told that waves moved more slowly in shallow water. This is why waves pile up and get bigger as they near the shore. We decided that we would test the effect of how deep the water is. The hypothesis I will test is: “Waves move more slowly in shallow water, because the ‘drag’ against the bottom slows them down.”

<u>The number of waves</u>.

In a ripple tank, the waves are made by a rod which is bounced up and down by an electric motor. This makes a series of waves and it was too difficult to keep track of which one was which. We needed a single wave, but we found it was difficult to move a stick in a consistent way. However, we found that if we put the container on a firm flat surface, lifted one end slightly then let it drop, we got one single wave which ran across the surface.

<u>Timing the waves</u>

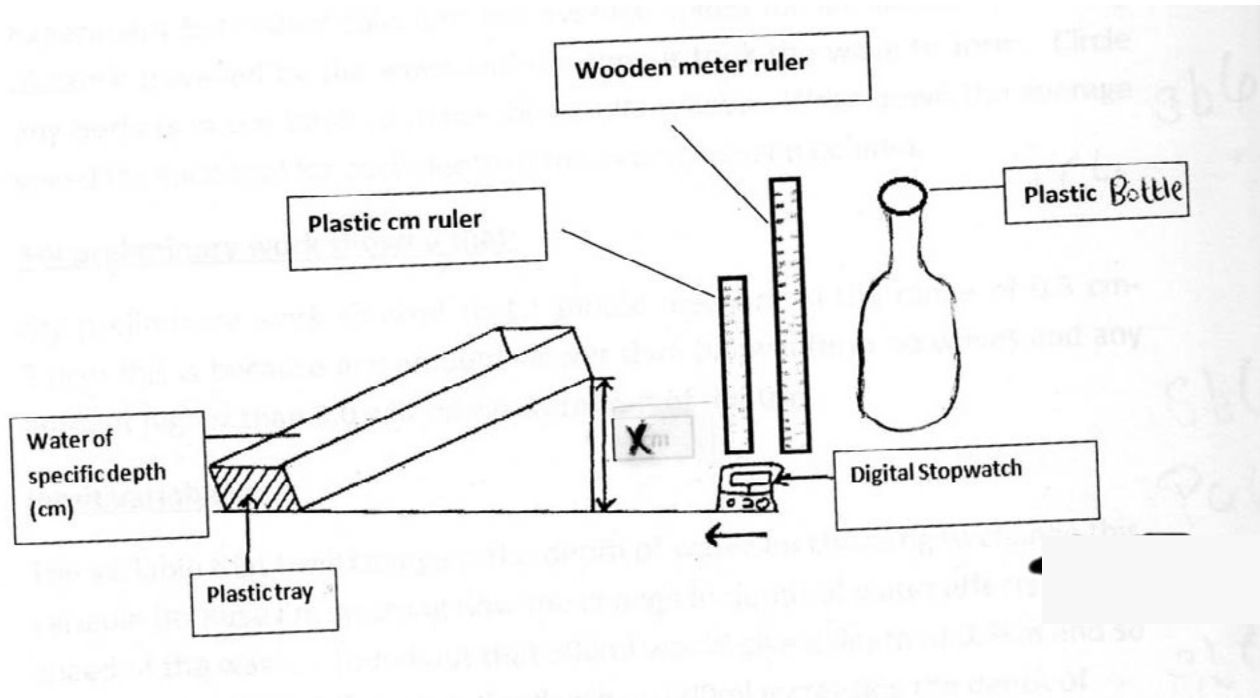
The biggest trough in our laboratory had diameter 50 cm. When we made a wave across it, the wave only took about 1 second to travel across. This was too quick to measure accurately.

We noticed that the wave bounced back from the other side of the trough, so we thought we could time it for several times across (like timing lots of swings with a pendulum). Because the wall of the trough was curved, the bounce-back wave got all jumbled up.

We decided to use the largest rectangular container we could find. This was a plastic toy tray, length 50 cm. width 35 cm, depth 20 cm.

<u>Preliminary experiments</u>.

We put about 5 cm depth of water in the toy-box and then tried dropping it from different heights.



The results that we got are on the next page.

Dropping from different heights

Height of end of box / cm	What happened
1	Wave faded after one length of box – too small
2	Wave too small
3	Wave lasted about 3 x up or down the box
4	Wave still going after 4 lengths
5	Wave OK
6	Other ripples formed as well
7	second wave formed – interfered after reflection
8	second wave formed

We decided that the best height for dropping the box was 5 cm.

How many 'wave bounces'?

The time for the wave to travel once along the box was too short to measure accurately. We let the wave bounce backwards and forwards from one end of the box to the other and counted how many lengths it went and measured the time. The water in the box was 5 cm deep for each try.

Number of lengths	1st try / seconds	2nd try / seconds	average / seconds	range as % of time
1	0.77	0.73	0.75	5%
2	1.48	1.53	1.505	3.3%
3	2.30	2.25	2.275	2.2%
4	3.00	3.08	3.04	2.7%
5	3.75	3.80	3.775	1.3%
6	4.60	4.45	4.525	3.3%
7	too many ripples – wave breaks up			

If we used more reflections, we could measure the time more accurately. However, the wave gets very weak. Each time it bounces it loses some energy. Also, each time some little ripples are formed and these begin to interfere with the wave and make it uneven or unstraight.

What my preliminary work showed

My preliminary work showed that I should use pure water and keep the temperature the same. I must use a box with straight sides and square corners, so that there would not be waves reflected at angles which break up the main wave. I then fill the toy box with water to the correct depth, then prop up one end to 5 cm. Then I carefully remove the blocks. I will measure for 5 lengths of the box.

Investigation

Method for main experiment

Apparatus:

Plastic toy box (50 cm x 35 cm x 20 cm)
Large plastic bottle
metre ruler
2 x wood blocks, 5 cm thick
thermometer
digital stop clock.

- First set up all the apparatus on the classroom experiment bench.
- Collect enough water in the large bottle and measure the temperature.
- Pour water into the toy box until it is 1.0 cm deep.
- Lift one end of the box onto the two wooden blocks.
- Leave to settle until the water is still.
- Grip the rim of the box at the high end. Someone carefully pull away the blocks.
- Let the box drop. As it hits the table, start the clock.
- Count the wave up and down the box for 5 lengths, then stop the clock.
- Repeat until three readings agree.
- Add more water until the total depth is 2.0 cm.
- Repeat the measurements.
- Continue to add water 1.0 cm at a time and repeat.

If the box wasn't dropped absolutely level, we got a wobbly wave that bounced around and broke up. We had to wait for the water to settle then repeat. We only recorded the times when we got a good, straight wave.

Once the experiments are over, calculate the average speed for each depth of water.

Results

Temperature of the water 17°C

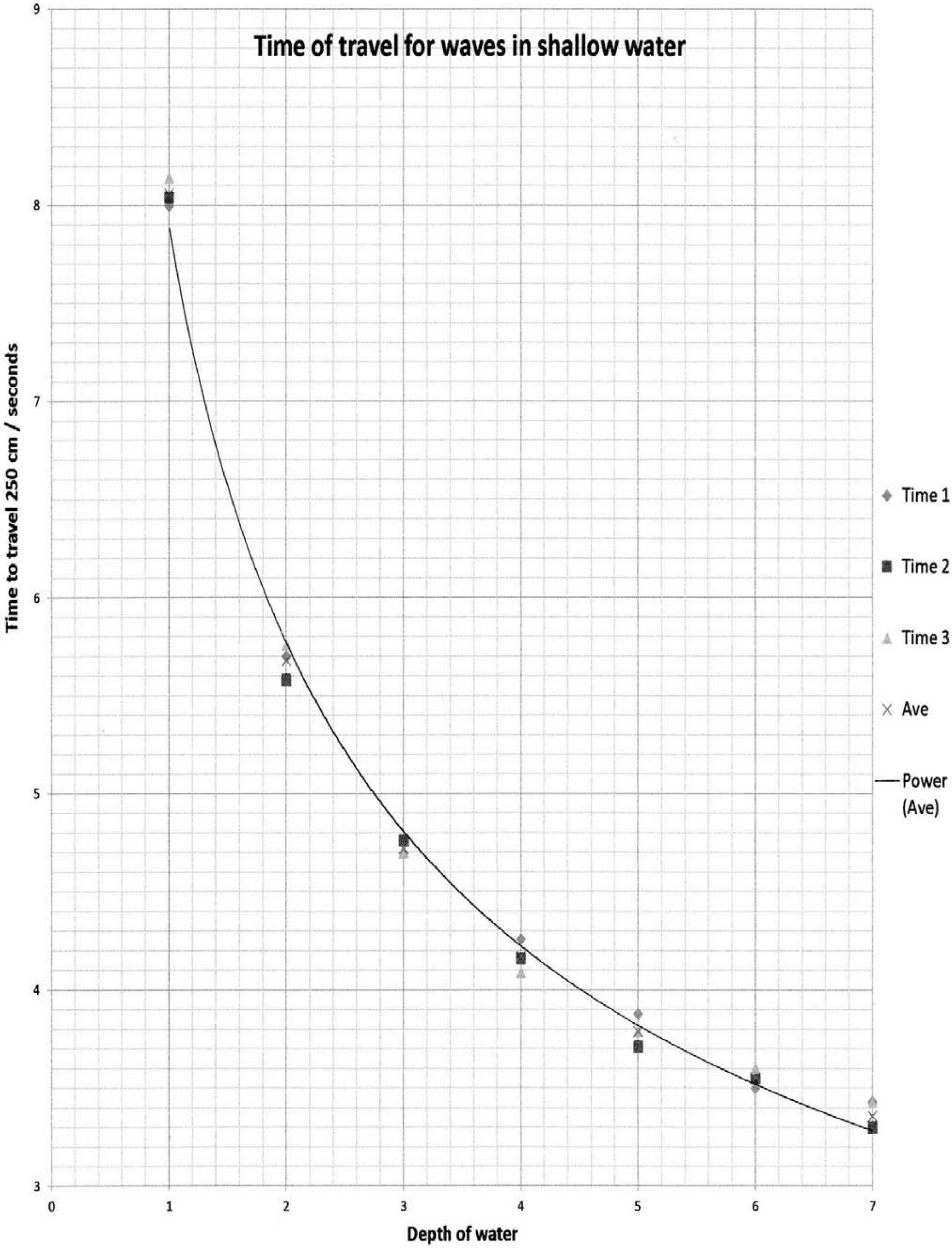
Length of tray = 50 cm

Total distance travelled by the wave = 5 x 50cm = 250 cm

Depth of water / cm	Time taken to travel 250 cm / seconds				Average speed cm/s
	1st attempt	2nd attempt	3rd attempt	Average	
1	8.00	8.04	8.14	8.06	31.0
2	5.70	5.58	5.76	5.68	44.0
3	4.70	4.76	4.70	4.72	53.0
4	4.26	4.16	4.09	4.17	59.9
5	3.88	3.71	3.79	3.79	66.0
6	3.50	3.55	3.60	3.55	70.4
7	3.43	3.30	3.43	3.36	74.4

See graph 1

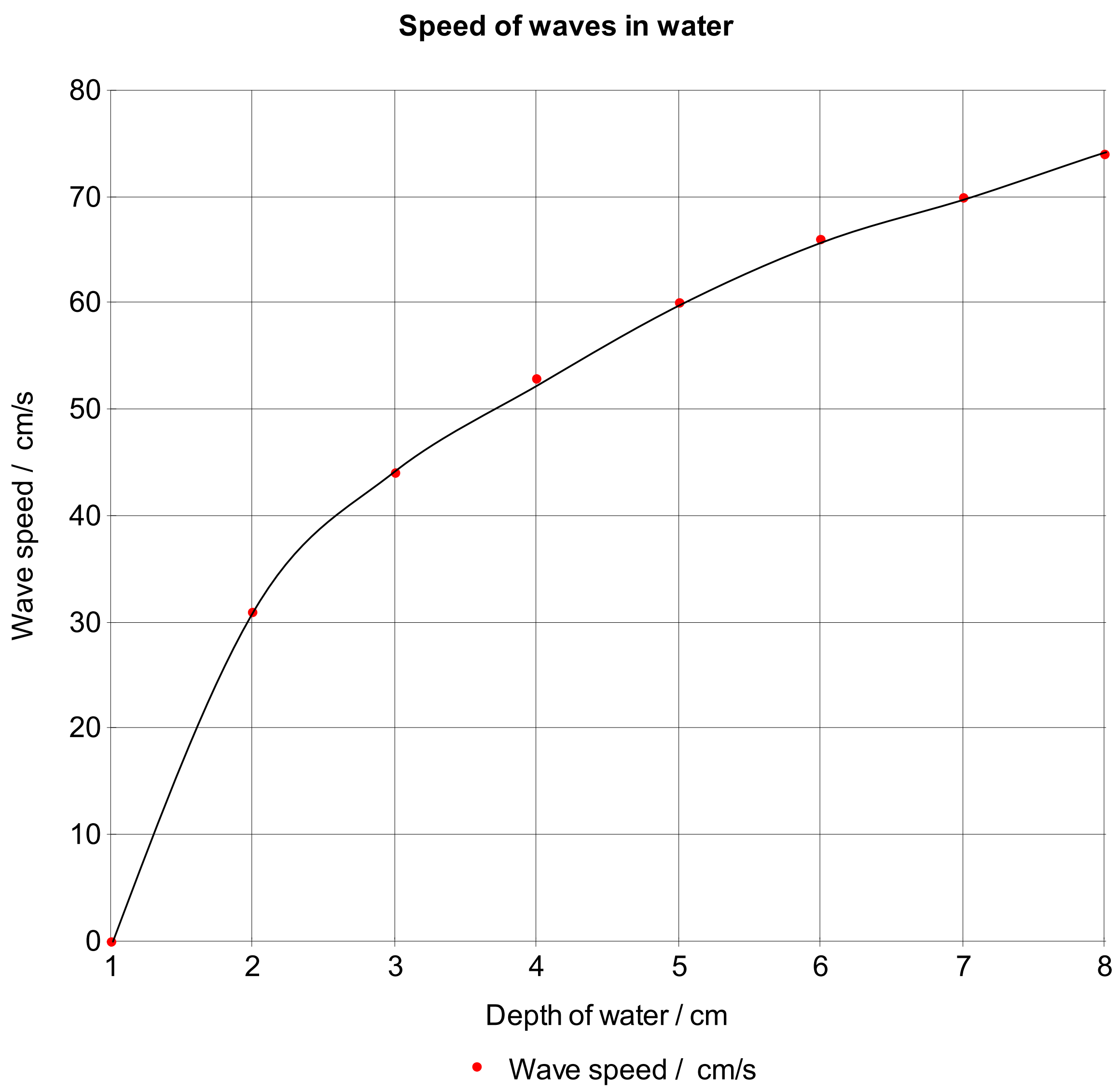
Investigation



5

Investigation

Graph 2



Conclusion:

Graph 2 shows clearly that as the water gets less deep, the wave moves more slowly. Waves approaching the shore slow down as the water becomes shallower. Because of this, the water piles up and the waves become bigger. If they are big enough, they may tip over (“break”) because the top of the water is moving fastest.

This is not a straight line relationship. At first the slope is steep. As the water begins to get deeper, the wave rapidly gets faster. However, the line becomes less steep and it looks as if there would finally be a limit where the wave has reached its maximum speed.

A graph of $y = c\sqrt{x}$ has a shape that looks rather like this one in graph 2,
where
y = wavespeed

c = a constant

x = depth of water so $\sqrt{x}$ is the square root of the depth

6

I tried out some of the numbers and this seems to nearly fit, with c = 30

for c = 30

Depth of water / cm	Square root of depth	calculation		observed speed
1	1.00	1 x 30 =	30	31
2	1.41	1.41 x 30 =	42.3	44
3	1.73	1.73 x 30 =	51.9	53
4	2.00	2.00 x 30 =	60	59.9
5	2.24	2.24 x30 =	67.2	66
6	2.45	2.45 x 30 =	73.5	70.4
7	2.65	2.65 x 30 =	79.5	74.4

This is not quite perfect, but it is quite a good fit. I can therefore suggest that the relationship between water depth and wavespeed depends on the square root of the water depth.

The slowing down may be because the shallow depth restricts the movement of the water molecules as the wave passes over, but I can't explain the exact shape of the graph.

Evaluation

Safety

There are no dangerous chemicals in this experiment. The box full of water is heavy. It should be gripped by the top rim and carefully released to avoid any risk of fingers underneath. It must also be dropped level, or the wave does not go straight and more waves may also be made. Be careful that water does not spill out and mop up any spills.

Method

It was difficult to drop the box cleanly and level. There were a lot of times when we didn't get a good clear wave, so we did not record any result for these. So for each height, we kept on doing it until we had three results that worked.

The depth of water was only measured with the end of a metre ruler and this is not very accurate. Afterwards we thought that we knew the area of the box (50 x 35 = 1750 cm^2) so we could have used measuring cylinders to put 1750 cm^3 of water into the box for each depth and this would have been a much better method.

We had to start and stop the stop clock by eye and this involves a reaction time error. I practiced starting and stopping it and found that I could do this in 0.2 seconds, so there may be this much error in the times. It was also difficult to decide exactly when the wave was formed and began to move. We tried to start as the box hit the table top. On the other hand, I did all the timing so that errors should be consistent and I could prepare for each start or stop because I knew when the box would drop and I could watch the wave approaching the end. I think we did the best we could for hand timing, and this is shown by the fact that the biggest range in any set of 3 results is only 0.18 seconds.

I am not sure that bouncing the wave off the ends of the box gives the same answer you would have for a single straight journey. It would be better to use a much longer trough and do a single straight run. However, we didn't have one. It would also have meant finding a different way to make a single wave, since we couldn't have dropped a very long trough.

Data

Graph 1 shows all of the results. All the repeat values are very close together (range 0.18 seconds or less) because we didn't record the results when we didn't get a single, straight-running wave. The points form a smooth curve and all lie on the curve. We have a range of 7 different depths which is enough to show the shape of the curve and that it isn't a straight line. I am confident that they are correct and consistent for the method we used.

To improve the investigation, we could work in a much larger pool, or continue up to greater depths to see whether the slope does actually flatten out to a steady final speed.

As I repeated the experiment three times for each depth it suggests a high level of accuracy and reliability in my results because it is very important for measurements to be repeated as if you look at only one value you cannot tell if it is reliable, however if you look at lots of measurements any errors will stand out.

Research for secondary data

Because I couldn't really explain my results properly, I searched on the internet to find information about "the speed of water waves". I took information from three different sites, and full references are at the end of this report.

Ref [1]:

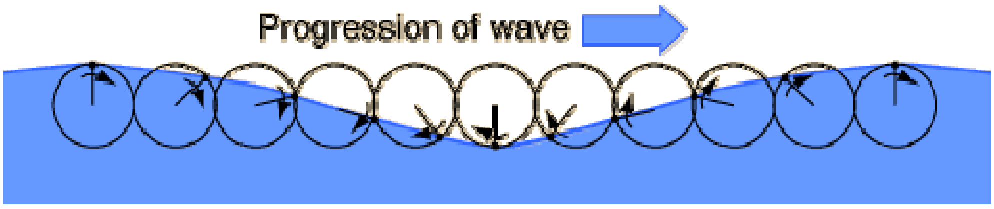
> The velocity of idealized traveling waves on the ocean is wavelength dependent and for shallow enough depths, it also depends upon the depth of the water. The wave speed is
>
> $$v = \sqrt{\frac{g\lambda}{2\pi}\tanh\left(2\pi\frac{d}{\lambda}\right)}$$
>
> λ = wavelength
> d = depth
> g = acceleration of gravity
>
> In deep water, the hyperbolic tangent in the expression approaches 1, so the first term in the square root determines the deep water speed. The limits on the tanh function are
>
> $$\tanh x \approx 1 \quad \text{for large } x$$
> $$\tanh x \approx x \quad \text{for small } x$$
>
> so the limiting cases for the velocity expression are
>
> $$v \approx \sqrt{\frac{g\lambda}{2\pi}} \quad \text{for deep water, } d > \frac{\lambda}{2}$$
> $$v \approx \sqrt{gd} \quad \text{for shallow water, } d < \frac{\lambda}{20}$$

This matches my results because it shows that in shallow water the speed of the wave is proportional to the square root of the depth of the water. This gives me greatly increased confidence that my results do show the right pattern.

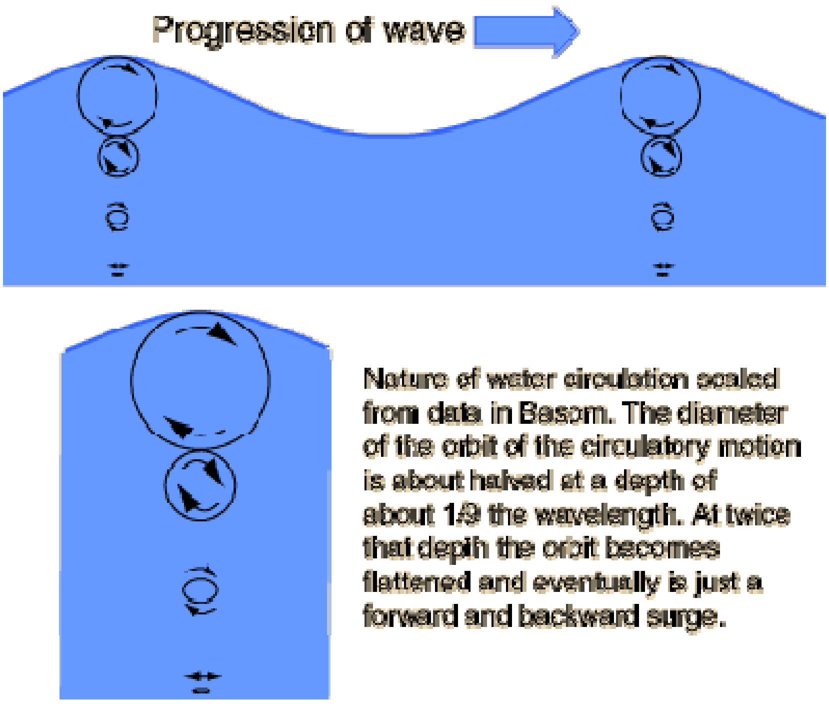
Except for very shallow water, the speed also depends on the wavelength of the waves.

Ref [1]

The motion of the water is forward as the peak of the wave passes, but backward as the trough of the wave passes, arriving again at the same position when the next peak arrives. (Actually, experiments show a slight advance of the water with the waves, but that advance is small compared to the overall circular motion.)



The illustration above, adapted from von Arx, shows the direction of the water motion at different points along the wave.

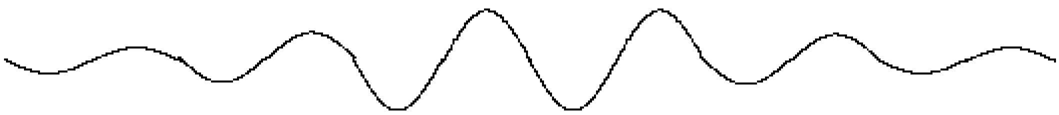


The circles summarize the total motion of the medium when a full wavelength passes. It was common practice to inject droplets of oil which were whitened with zinc oxide and adjusted to have the same density as the water. The orbits could then be traced out on the sides of the wavetank. It was found that there was a small progression of the orbits in the direction of the wave propagation.

This shows how the water moves as waves pass over the sea. The motion has an effect even down to quite a deep depth, which explains how it might be affected by the water getting shallower.

Ref [2]

Real waves do not travel as perfect sine waves, they travel as sets of waves, sometimes multiple sets of waves overlap and add together. Let me show you a drawing of one possible simple set of six waves.



A set of six waves.

If you watch such a set moving out from the wake of a boat for example you'll see something interesting. The set of waves moves. Imagine that the set of wave shown above is moving to the right. But the individual wave crests that make up the set move within the set. If you watch real waves closely you will see that a wave is born at the back side of the set, on the left, and then moves to the right twice as fast as the whole set is moving. It grows in amplitude until it reaches the middle of the above set, then it continues to the right shrinking in amplitude and disappearing at the front end of the set.

There are thus two velocities of travel associated with a deep water wave, the velocity of an individual peak, called the phase velocity, Cp, and the velocity of sets of waves called the group velocity, Cg. In theory, for deep water waves the phase velocity is exactly twice the group velocity.

All the stuff I found about waves was really about complete patterns of waves over the sea, but in our experiments we made just one single wave, so perhaps our results would not behave in exactly the same way.

Ref [3]

In words why this is the case -- for a shallow fluid, the motion of the fluid is mostly side-to-side, and in order to accumulate more fluid in one place (to make the crest of the wave), each little bit of fluid must travel a little farther than it would have to in deeper water. When a wave passes, the bits of fluid, if you could watch one at a time, travel in ellipses. For shallow water, the ellipses are stretched out horizontally, and in very deep water, they are very nearly circular. So for a wave of the same height (top to bottom of the ellipse), the bits of water must travel farther in the shallow tray than the deep tray. Because the waves of the same height in shallow and deep water exert the same pressure differences due to gravity to get the water moving (although the motion is different due to the fact that the bottom is there), similar forces push and pull on the water. To get the water moving farther and faster with the same force takes a longer time for each push, and hence a slower speed for the wave, in the shallow water.

Note: this speed formula assumes that the waves are small -- for waves whose heights are comparable to the depth of the tray, you will get even more complicated behaviour -- the most spectacular of these is the formation of "breakers" where the waves will curl over and crash as they do on beaches.

Final conclusion:

I can now conclude quite confidently that the speed of a water wave in shallow water is directly proportional to the square root of the water depth. This is the formula given on several academic web-sites and agrees with the pattern of my experiment results.

In my shallow box, where the water is at a constant depth, our waves lose energy by becoming smaller. We could see that this was happening because it got harder to be certain where the top of the wave was as it moved backwards and forwards. But it kept going at the same speed, and I think this is the most interesting thing of all about the experiments.

The numbers that we got for the speed didn't exactly match the ones calculated from the formula. We did our measurements in a quite narrow box, so the sides may have an effect on the way the wave moves. We also used just a single wave, not a set of waves. Web site [1] also points out some other facts about 'real' waves –

> While this wave speed calculation may be a good approximation of the experimental wave speed, it cannot be depended upon as a precise description of the speed. It presumes an ideal fluid, level bottom, idealized waveshape, etc. It is also the speed of a progressive wave with respect to the liquid and therefore does not include any current speed of the water. In technical literature, this speed with respect to the liquid is called the "celerity" of the wave.

While I was looking for this information, I also found information about how tsunamis are formed and why they travel so fast and get so big as they reach the shore. I also found out how the shape of a beach fixes what sort of surf will be formed and why it can be very difficult to escape from surf because of the undertow of water back from the beach as the waves break.

References:

[1] http://hyperphysics.phy-astr.gsu.edu/hbase/watwav.html

HyperPhysics (©C.R. Nave, 2010) is a continually developing base of instructional material in physics. It is not freeware or shareware. It must not be copied or mirrored without authorization.

Carl R. (Rod) Nave, Department of Physics and Astronomy, Georgia State University

[2] **http://www.exo.net/~pauld/activities/waves/waterwavespeed.html**

[3] http://van.physics.illinois.edu/qa/listing.php?id=2223

Physics Questions? Ask the Van

Department of Physics, University of Illinois, Urbana-Champagne

Commentary - Investigation Title: Waves in Water

Strand/Aspect	Mark	Comments
S(a) - formulate a hypothesis or prediction	6	Some factors that may affect the speed of a wave are considered and one factor selected. Some knowledge of waves is used to develop a hypothesis although the hypothesis does not lead to a quantified prediction. There is correct use of some specialist terms and the work is well organised with no significant errors in spelling, punctuation or grammar. Clearly meets 5-6 criteria, but the lack of a quantitative prediction and any consideration of wavelength or frequency means the 7-8 criteria are not met.
S(b) - design of techniques and choice of equipment	5	Basic equipment of plastic tray, meter ruler and stopwatch used and shape of tray and choice of water as the most appropriate liquid decided from preliminary work. But little explanation of the range of depths chosen. Some risks identified and vague precautions suggested. Just meets 5-6 marking criteria but 5 marks only
C - range and quality of primary data	7	The selected range of depths of water in the tray appear appropriate to give suitable differences in times / speeds. Regular repeat measurements are taken for each depth. From inspection of the graph the data are of good quality and the preliminary work was used to inform the main experiment in the choice of liquid to use, the shape of the tray, the drop height and the number of 'wave bounces'. Meets 7-8 criteria but the preliminary work was not used to establish the best range of depths so 7 marks awarded.
A - revealing patterns in data	7	For graph 1 the points are correctly plotted, the axes suitably scaled and labelled (although missing units on x-axis), good line of best fit and all data plotted including repeats and averages. Graph 2 has a scaling error on the x-axis. Meets 7-8 criteria, but careless errors suggest 7 marks more appropriate
E(a) - evaluation of apparatus and procedures	6	Describes how the data was collected and identifies problems in measuring the depth of water accurately, timing errors in the use of the stopwatch and the limitations of the 'bouncing wave' technique in a small trough. The problem of dropping the box in a more consistent method is not referred to. Suggests improvements to measure volume rather than depth of water with measuring cylinders but suggestions to produce a more consistent single wave are not described. Fully meets the criteria at 5-6, 6 marks awarded.
E(b) - evaluation of primary data	6	The reproducibility of repeat measurements is very good but the candidate does acknowledge that 'we didn't record the results when we didn't get a single, straight-running wave' so potential anomalies are implicitly recognised, explained and eliminated at this stage. Suitable comments about reliability and accuracy of the data collected are made. On the border between 5-6 criteria and 7-8 criteria, but the lack of specific reference to outliers means 6 marks is more appropriate, as the outliers are only accounted for by implication.
R(a) - collection and use of secondary data	6	The candidate has provided three pieces of secondary data, all of which are relevant to the investigation. The sources are well referenced, but of limited variety. There is discussion of the extant to which the secondary data agrees with the primary data. However little comment on the importance of similarities and differences. Criteria for 5-6 are fully met, Hence 6 marks awarded.

Strand/Aspect	Mark	Comments
R(b) - reviewing confidence in the hypothesis	7	Considers how the primary data fit to the original hypothesis. The hypothesis is revised to link wave speed to the square root of depth. Additional data to be collected related to the hypothesis is suggested, but little detail is given. The report is logically sequenced, using scientific terminology with few grammatical errors. Just meets 7-8 criteria. 7 marks awarded
Total:	**50/64**	

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