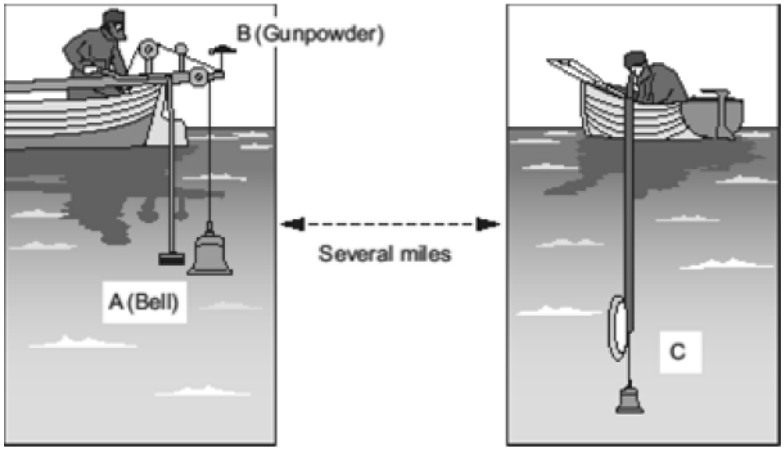
1(a). Nearly 200 years ago an underwater bell was used to find the speed of sound under water in Lake Geneva, Switzerland.



The bell (**A**) was struck and the gunpowder (**B**) ignited at the same time. The flash from the gunpowder and the sound from the bell were picked up several miles away (**C**).

What **two** measurements need to be taken in this experiment in order to calculate the speed of sound under water?

---

[2]

(b). The flash from the gunpowder was seen before the sound of the explosion was heard.
Explain why this happened in terms of the speed that sound and light travel.

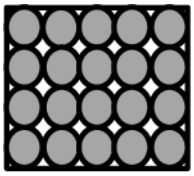
---

[1]

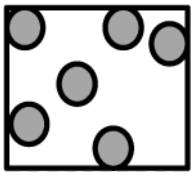
(c).

(i) Below are diagrams showing the particle arrangements in solids, liquids and gases.

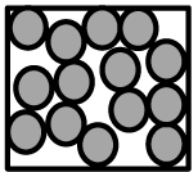
Match the diagram to the correct label.



Gas



Liquid



Solid

[2]

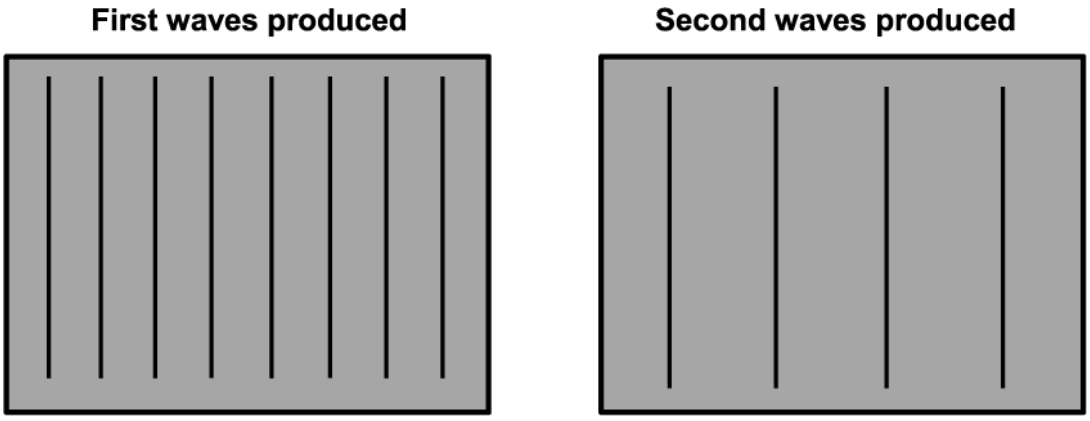
(ii) Sound waves travel through materials by making the particles in the material vibrate.

Use this idea and your knowledge of the particle model of matter to explain why sound travels much faster through water than through air.

---

[2]

2(a). Rob is experimenting with water waves. He uses a wave generator to create waves at different wavelengths and frequencies. Below are diagrams showing the waves he produced. Each line represents a wave viewed from above.



Fill in the gaps below to explain how the wave has changed.

(i) The wavelength of the second wave produced is _____ than the first wave.

[1]

(ii) The frequency of the second wave produced is _____ than the first wave.

[1]

(b).

(i) Rob times the waves as they pass in front of him.

He finds that 5 waves pass him in 10 seconds.

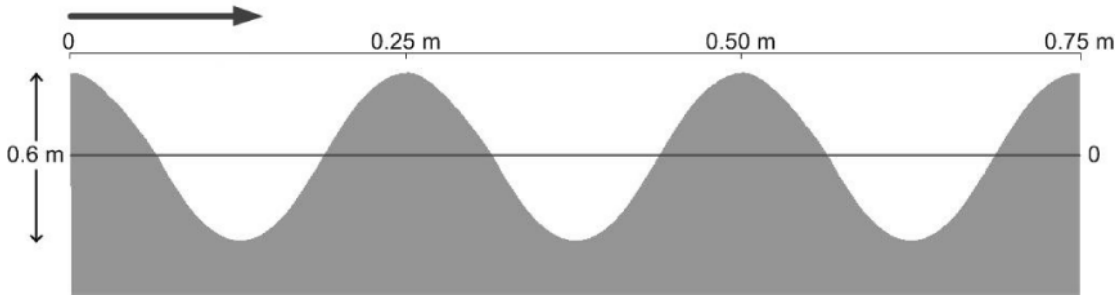
Calculate the frequency of the wave.

_____ Hz **[2]**

(ii) Using your answers to parts **(b)** and **(c)(i)** calculate the speed of the wave.
In your answer use the equation:
wave speed = frequency × wavelength

_____ m/s **[2]**

(c). The image below shows the second wave produced but seen from the side



Use data from the diagram above to calculate the amplitude and the wavelength of the water waves.

Show your working.

amplitude = _____ m wavelength = _____ m **[3]**

3. Here are some sentences about how lenses bend light.

Put a (ring) around the correct choice to complete each sentence.

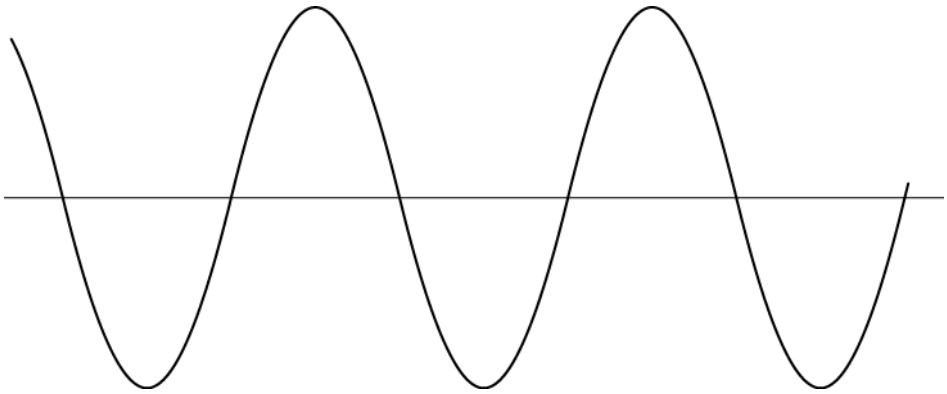
When light enters a lens the **colour / frequency / speed** of the light changes.

This change causes a change in the **amplitude / frequency / wavelength** of the light, which can cause the light to bend.

If the light ray is at right angles to the surface of the lens the light ray is **bent / not bent / stopped**.

[3]

4(a). The diagram shows the side view of a wave.



(i) On the diagram clearly label the **wavelength** and the **amplitude**.

[2]

(ii) An earthquake wave passes through the Earth's **core**.

What type of wave is it?

Put a tick (✓) in the box next to the correct answer.

electromagnetic	☐
P-wave	☐
S-wave	☐

[1]

(b). An earthquake wave travels at a speed of 5 km/s for 110 seconds.

A scientist estimates that the earthquake was 500 km away from the detector.

Is the scientist correct?

Justify your answer.

---

[2]

5(a). Earthquakes close to the coast often produce dangerous water waves called tsunamis.

The table below gives typical data for a tsunami.

Depth of water (metres)	Speed (metres per second)	Wavelength (km)
7000	260	282
4000	200	213
200	45	48
10	10	11

The Indian Ocean is 4000 m deep.

(i) How fast do tsunamis travel in the Indian Ocean?

speed = _____ metres per second **[1]**

(ii) A tsunami took 30 000 seconds to cross the Indian Ocean.
Calculate the distance travelled by the tsunami. Give your answer in kilometres.
Show your working.

distance = _____ km **[2]**

(b).

It has been suggested that the speed of a tsunami is directly proportional to the depth of the water.

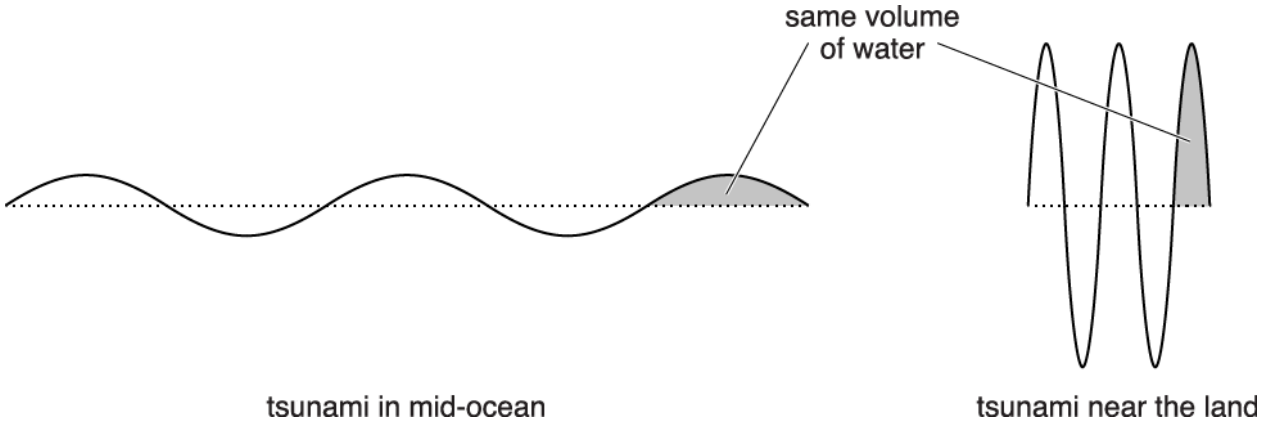
Explain what **directly proportional** means and use the data in the table below to see if the suggestion is true.

Speed (metres per second)	Depth of water (metres)
45	200
10	10

[2]

(c).

The diagram below shows the tsunami waves in mid-ocean and near the land. The volume of water in each 'peak' of the wave stays the same.



Explain why a tsunami may not be noticed by a ship in mid-ocean but can cause terrible damage when it strikes the land.

[2]

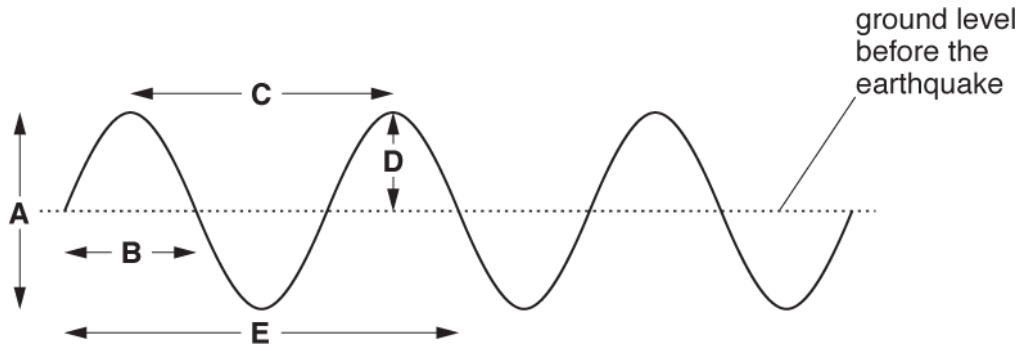
6. What is the name for what happens to light at a mirror?

Put a (ring) around your answer.

absorption diffraction reflection refraction

[3]

7. The diagram below shows the ground moving when an earthquake wave passes. The dotted line shows the ground level before the earthquake arrived.



The wave diagram has five different arrows labelled **A, B, C, D** and **E.**

(i) Which arrow, **A, B, C, D** or **E**, shows the **amplitude** of the wave?

the amplitude is shown by arrow ---------- **[1]**

(ii) Which arrow, **A, B, C, D** or **E**, shows the **wavelength** of the wave?

the wavelength is shown by arrow ---------- **[1]**

(iii) The wave in the diagram has a wavelength of 1 km and a frequency of 2 Hz.

Calculate the speed of the wave in m/s.

Show your working.

speed = ---------- [2]

[Total: 7]

8(a). Jamal is listening to the radio.

He can hear a musical instrument playing a steady note.

What type of wave is the **sound** that Jamal hears?

Put a (ring) around the correct answer.

electromagnetic **longitudinal** **radio** **transverse**

[1]

(b). The sound waves that Jamal hears have a frequency of 400 Hz and a wavelength of 0.84 m.

Calculate the speed of the sound waves.

Use the equation: wave speed = frequency × wavelength

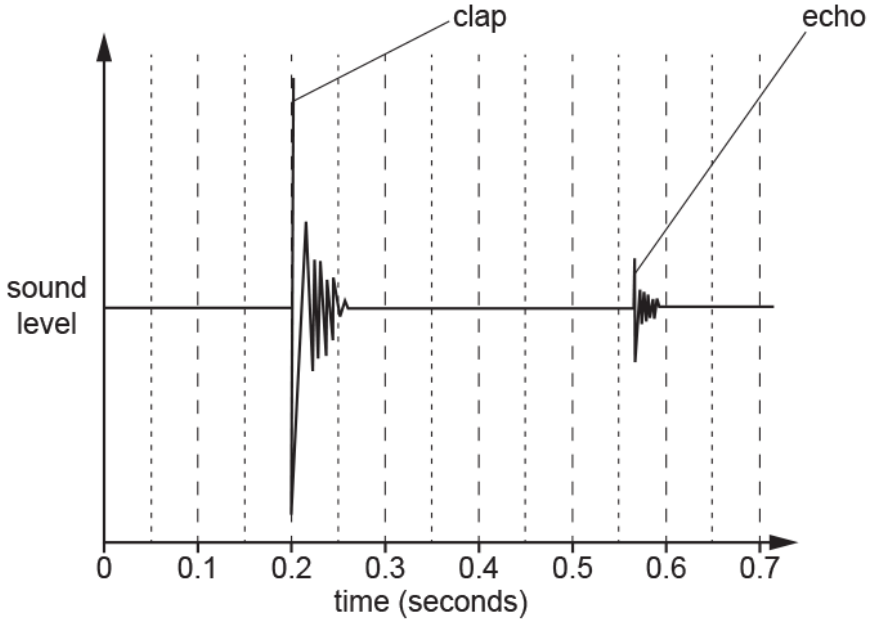
Wave speed = ... m/s [2]

9(a). Over 300 years ago, Isaac Newton measured the speed of sound in air in a long outdoor corridor.

Eve and Ali repeated this experiment by measuring the time between a clap and its echo.

Eve clapped her hands, and Ali timed with a tablet computer.

The computer recorded the sound of the clap and its echo and produced the graph below.



(i) What time was the sound of the **clap** recorded?

Time = ---------- seconds **[1]**

(ii) What time was the sound of the **echo** recorded?

Time = ---------- seconds **[1]**

(iii) Calculate the time of travel for the sound wave to go from Eve to the wall and to return to the computer.

Time of travel = ---------- seconds **[1]**

(b). The distance from Eve to the reflecting wall is 64 m.

Explain how you can use the distance, together with a time from part a), to calculate the speed of sound.

You do not have to include the calculation.

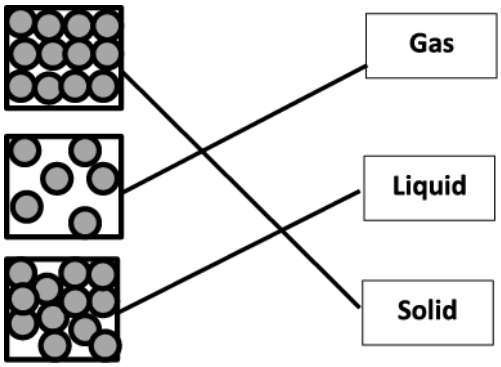
---[2]

(c). Isaac Newton's value for the speed of sound was less accurate than the one given by this method.

Suggest and explain why Newton could not get an accurate answer.

---[2]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		Distance from A to C (1) Time taken for sound to reach C (between flash and sound being picked up) (1)	2	unqualified 'distance' and 'time' = 1 mark only
	b		Light travels faster than sound	1	**allow** reverse argument
	c	i		2	1 correct 1 mark 2/3 correct 2 marks
		ii	In water (liquids) the particles are closer together ….. (1) ….makes it easier for vibrations to be transmitted (1)	2	must be comparative e.g. less separation must be comparative e.g. more easily
			Total	**7**	
2	a	i	Larger / greater / bigger	1	
		ii	Less / smaller	1	
	b	i	Frequency = 5 ÷ 10 Hz (1) = 0.5 (Hz) (1)	2	
		ii	**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 0.125 m/s award 2 marks** = 0.5 Hz × 0.25 m (1) = 0.125 m/s (1)	2	**ecf** own frequency and wavelength
	c		Amplitude = 0.6 ÷ 2 (1) = 0.3 (m) (1) Wavelength = 0.25 (m) (1)	3	
			Total	**9**	

Question			Answer/Indicative content	Marks	Guidance
3			speed wavelength not bent	3	Examiner's Comments This question addressed syllabus statements in P7.2 Light, telescopes and images. Most candidates were able to apply the formula: power = 1/focal length or use the relationships in the data table to deduce one or both of the correct answers in the first part of this question. In part 2 of the question, candidates were required to choose the lens that would be the best objective lens for a telescope. Many candidates correctly identified the lens with the largest diameter (D) but very few were able to relate this large size to the increased amount of light that it would capture. In the third part of this question, candidates were required to identify three changes to light as it enters a lens at right angles to the surface by circling the correct word. Many candidates were able to identify that wavelength would change but only the most able recognised that this was due to the change in speed. The third mark is more difficult to analyse but it would appear that the term ‘at right angles to’ has confused most candidates.
			Total	3	

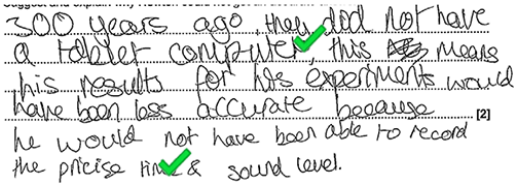
Question			Answer/Indicative content	Marks	Guidance
4	a	i	**wavelength** – horizontal, a single cycle of the wave indicated **amplitude** – vertical from the centre line to peak or trough	2	do not award marks if not labelled accept w or ? for wavelength and A or a for amplitude Examiner's Comments Many candidates knew the answers for wavelength and amplitude but sloppy lines and inaccurate or missing labels deprived them of the marks. The best responses were ones where lines were drawn with a ruler and end points clearly indicated rather than just an arrowhead in a general region of space.
		ii	electromagnetic P-wave ? S-wave	1	Examiner's Comments The majority of candidates gained this mark.
	b		(5 × 110) = 550 km (1) yes 500 is close to 550 / No 500 is different from 550 (1)	2	allow similar for calculation and comparison of speed (= 4.5km/s) or time (= 100s) a correct unit must be seen somewhere in the answer to score the first mark must have correct comparison for second mark allow ecf from calculation Examiner's Comments The majority of candidates realised a calculation was necessary but a number omitted units. Only the best responses made a clear comparison with the other data from the stem of the question, with others making remarks that were insufficient to show clear understanding of why the calculated figure gave support to the statement or not. Candidates were expected to compare their answer with the specified estimate.
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
5	a	i	200 (m/s)	1	?Examiner's Comments?? Most candidates correctly read the speed of the tsunami from the table.
		ii	distance = speed × time = 200 m/s × 30 000 s = 6 000 000 (m) = 6000 (km)	2	6000 (2) ecf wrong speed in (a)(i) if not (2) then EITHER 6 000 000 or 200 × 30 000 (1) OR allow correct conversion from m to km (1) ?Examiner's Comments?? Candidates who were able to calculate the speed generally forgot to divide by 1000 to convert their answer to kilometres.
	b		If you divide the speed by the depth (or vice versa) you get the same value OR you plot a graph, it's a straight line though the origin OR speed = constant x depth (1) use of data to show that it is not true (1)	2	proposing a test (which includes attempting to perform it) e.g. dividing one variable by the other, or sketching a graph, gets the first mark 2nd mark needs application of the test (which could be an annotated sketch graph or 45/10 is not 200/10) ?Examiner's Comments?? Candidates did not know the meaning of directly proportional. Many were able to state that as one quantity increased the other also increased and many others assumed that it meant the two values were the same. Parts b) and c) were on both the higher and foundation paper, and were some of the more difficult questions on the foundation paper.

Question			Answer/Indicative content	Marks	Guidance
	c		The amplitude is bigger on the shore OR smaller in mid-ocean (1) Wavelength gets smaller OR waves bunch more / waves slow down as they approach land (1) Large amplitude means more (potential) energy (to cause damage) (1) Waves go further inland OR can get over barriers (1)	2	any two points large amplitude could be taller / higher wave but **ignore** bigger waves; could describe vertical motion of e.g. ship **ignore** frequency change **ignore** kinetic energy e.g. can cause flooding inland Examiner's Comments?? Candidates often gave their answers in terms of 'bigger waves' and it was not possible to credit this as they had not explained whether they were referring to the wavelength or to the amplitude. Those that did use the correct terms generally scored marks. There was a misconception that the frequency would change, presumably because the wavelength had changed. Candidates did not realise the significance of the earlier part of the question – i.e. that the speed had also changed. Other candidates wrote that, 'The wave speeds up as it approaches land.' Several candidates tried to answer in terms of P and S waves.
			Total	7	
6			reflection	1	?Examiner's Comments? Most candidates could identify 'reflection' as the name for what happens to light at a mirror.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
7		i	C	1	
		ii	B	1	
		iii	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 2000 (m/s) award 2 marks if answer = 2 (m/s) award 1 mark 1 km = 1000 m (1); speed (= frequency × wavelength) = 2 (Hz) × 1000 (m) = 2000 (m/s) (1)	2	Needs use of equation & evaluation of own values of λ and A for this mark, e.g. λ = 100 m and speed = 200 m/s would get m.p.2 (ecf) only, as m.p.1 has a conversion error.
			Total	4	
8	a		longitudinal ✓	1 (AO 1.1)	electromagnetic **longitudinal** radio transverse Examiner's Comments Candidates needed to read this question carefully not to be misled by the first sentence, as the most common error was to choose 'radio' as the response. The only type of waves which are 'heard' are sound waves and they are longitudinal.
	b		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 336 (m/s) award 2 marks 0.84 × 400 ✓ = 336 (m/s) ✓	2 (AO 2.1 ×2)	ALLOW 340 (m/s)
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
9	a	i	0.2 (seconds) ✓	1 (AO 2.2)	± 0.01 s
		ii	0.57 (seconds) ✓	1 (AO 2.2)	± 0.01 s
		iii	0.37 (seconds) ✓	1 (AO 2.1)	**ECF** values from ai and aii Examiner's Comments Most candidates where able to answer part (i) but some of the lower ability candidates were outside the range for part (ii). Part (iii) proved more challenging for some lower ability candidates.
	b		Recall: v=s/t ✓ Realises that you have to double the distance / half the time ✓	2 (AO 1.2) (AO 2.1)	**ALLOW** in words Examiner's Comments Many candidates correctly gave the equation speed = distance ÷ time. Some lower ability candidates thought it was distance × time, and a few thought that they were being asked to describe an experiment. Hardly any candidates said that the distance was twice the distance from Eve to the wall.

Question			Answer/Indicative content	Marks	Guidance
	c		His value of time was inaccurate ✓ Did not have accurate clock/computer ✓	2 (AO 3.1b) (AO 3.2b)	**ALLOW** other valid suggestion **ALLOW** 'did not have the technology' <u>Examiner's Comments</u> Most candidates realised that Newton would not have had a computer, but very few said that this would make his value of time inaccurate. Most repeated that not using a computer would make his value for the speed inaccurate. Some lower ability candidates thought he might have had difficulty doing the calculation 'in his head' or 'without a calculator' or that he might have 'timesed (sic) instead of divided'. Exemplar 1 shows one of the few responses that scored both marks. Exemplar 1 
			Total	7	