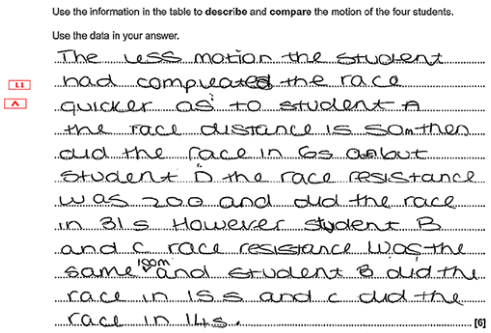
Mark scheme – Motion (F)

Question			Answer/Indicative content	Marks	Guidance
1			**B** ✓	1 (AO2.1)	**Examiner's Comments** This proved to be the easiest question in Section A, with about 85% of all candidates getting it right. The commonest wrong answer was D.
			Total	**1**	
2			**D** ✓	1 (AO1.2)	
			Total	**1**	
3			**C** ✓	1 (AO2.1)	
			Total	**1**	
4			**C** ✓	1 (AO1.2)	**Examiner's Comments** Nearly half of the candidates did get the right answer. However most of the other candidates appeared to have been just guessed which response was correct.  **AfL** Standard form is tricky for Foundation Tier candidates. Try using low stakes pop quizzes and starter exercises to embed concepts of standard form and the metric prefixes. See also the Mathematical Skills Handbook http:/www.ocr.org.uk/Images/310651-mathematicalskills-handbook.pdf
			Total	**1**	
5			**C** ✓	**1 (AO 2.2)**	**Examiner's Comments** Candidates were required to carry out a simple substitution into a given equation were generally answered well. The most common error was not squaring the speed and choosing distractor B.
			Total	**1**	
6			**B** ✓	1(AO2.1)	
			Total	**1**	

7			**B** ✓	1(AO1.2)	**Examiner's Comments** This involves two different unit conversions, km to m and h to s. Many successful candidates used the space to set out step-by-step intermediate calculations..
			Total	**1**	
8			**D** ✓	1 (AO1.2)	**Examiner's Comments** The majority of candidates correctly identified that a ruler and a stopwatch should be used to measure the speed of water waves. A common incorrect response was an ammeter and stopwatch.
			Total	**1**	
9			**C** ✓	1 (AO2.1)	
			Total	**1**	
10			B	1 (AO2.1)	
			Total	**1**	
11			A	1 (AO2.1)	
			Total	**1**	
12			A	1 (AO1.1)	
			Total	**1**	
13			Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Detailed description and comparison of the motion of all four students in terms of distance and time relating speed to distance run **AND** Calculates the speed of all four students. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Description and comparison of the motion	6 (AO2 × 1.1) (AO2 × 2.2) (AO1 × 3.1a) (AO1 × 3.2b)	**AO1.1 Demonstrate knowledge and understanding of the correct formulae** • speed = distance ÷ time • v = s ÷ t • evidence of calculation **AO2.2 Apply knowledge and understanding of the motion of the four students** • Race B is a longer distance than race A • Race B and C are the same distance • Students B & C take different amounts of time • Student D takes the longest time • Race D is the longest distance

			of three students of distance and time **OR** Calculates the speed of at least three students. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Brief description of the motion of at least three students. **OR** Calculates the speed of at least one student. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*		• Race A is the shortest distance • Student A speed = 15÷6 = 8.3m/s • Student B speed = 100÷15 = 6.7m/s • Student C speed = 100÷14 = 7.1m/s • Student D speed = 200÷31 = 6.5m/s **AO3.1a & AO3.2b Analyse information to interpret and draw conclusions about the motion of the four students** • Race B is twice the length of race A, but time is more than twice that of race A • C is faster than B as the time is shorter (for the same distance) • As race length increases, average speed decreases **Examiner's Comments** There were many excellent answers, with the mean speeds of all four runners calculated with comments about how they had run different races (apart from B and C). Many candidates helped themselves by annotating the calculated speeds next to the table). The most able candidates discussed the effect of running a longer race on the mean speed of the runner (see Exemplar 7 below). Less able candidates compared the times of each runner but did not calculate speeds (see Exemplar 5 below). **OCR support** About one in ten candidate did not attempt to answer this question. Level of Response (LoR) questions are designed to open up the potential answers so that candidates at all levels of ability have an opportunity to show their scientific understanding. Every candidate should be encouraged to answer LoR questions as even a weak but relevant answer will be credited. The 'How to answer 6 mark LoR questions' resource can be used to help candidates prepare for this style of question http:/www.ocr.org.uk/Images/374902-how-to-answer-6-mark-lor-activity.doc

Exemplar 5



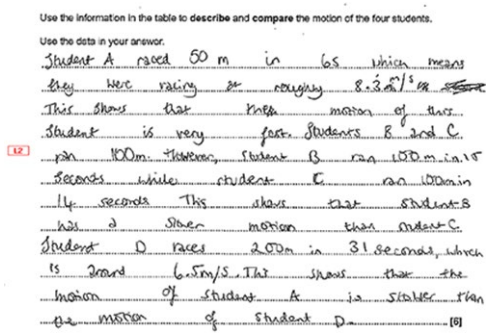
Use the information in the table to **describe** and **compare** the motion of the four students.

Use the data in your answer.

The less motion the student had compleated the race
L1
quicker as to student A
A
the race distance is 50m then
did the race in 6s about
student D the race resistance
was 200 and did the race
in 31s however student B
and C race resistance was the
same 100m and student B did the
race in 15s and C did the
race in 14s. [6]

A Level 1 candidate response. They describe the data in the table with no attempt to process data and calculate the speed of each runner. The information is relevant to the question but there is no real attempt to compare the motion of the four students.

Exemplar 6



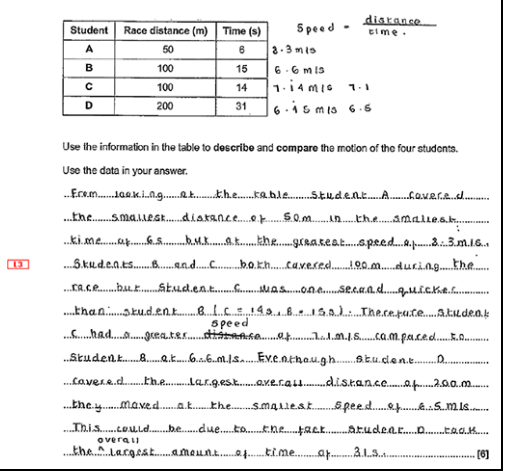
Use the information in the table to **describe** and **compare** the motion of the four students.

Use the data in your answer.

Student A raced 50 m in 6s which means
they were racing at roughly 8.3m/s ~~or~~
This shows that their motion of their
Student is very fast. Students B and C
L2
ran 100m. However, Student B ran 100m in 15
seconds while student C ran 100m in
14 seconds This shows that Student B
was a slower motion than student C.
Student D races 200m in 31 seconds, which
is round 6.5m/s. This shows that the
motion of student A is slower than
the motion of student D. [6]

A Level 2 candidate response. They have calculated and compared the speeds of A and D, but only compared the relative motions of B and C. There is a structured line of reasoning and the reporting of data is linked by sentences that offer some interpretation of the facts.

Exemplar 7

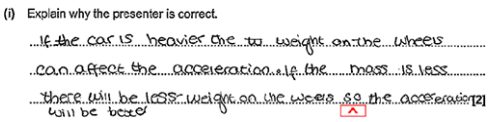
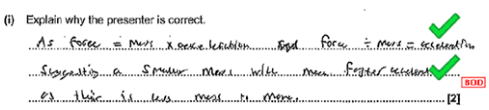


Student	Race distance (m)	Time (s)	Speed = distance / time
A	50	6	8.3 m/s
B	100	15	6.6 m/s
C	100	14	7.14 m/s 7.1
D	200	31	6.45 m/s 6.5

Use the information in the table to **describe** and **compare** the motion of the four students.

Use the data in your answer.

From looking at the table Student A covered
the smallest distance of 50m in the smallest
time of 6s but at the greatest speed of 8.3m/s.
L3
Students B and C both covered 100m during the
race but Student C was one second quicker
than student B (i.e 14s < 15s). Therefore student
C had a greater speed distance of 7.1m/s compared to
Student B at 6.6m/s. Even though student D
covered the largest overall distance of 200m
they moved at the smallest speed of 6.5m/s
This could be due to the fact Student D took
overall
the largest amount of time of 31s. [6]

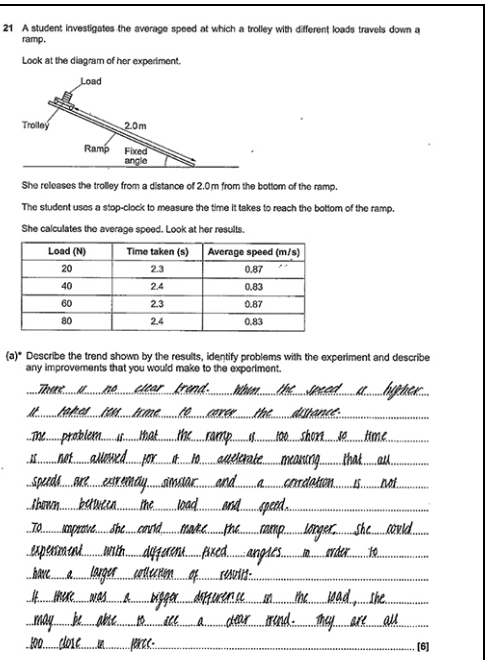
					A Level 3 candidate response. They first calculated the speed of each student and then annotated the data table. This allowed them to be more focused and precise in their response. They have offered some explanation of the relative motions of the students. This answer is logical and all the content is relevant. The word counts for all three exemplars are similar and demonstrating that a well thought out answer is better than a very long answer.
			Total	**6**	
14		i	*F* = *ma* / force equals mass times acceleration ✓ so reducing mass means the same engine force will cause greater acceleration ✓	2 (AO1.2) (AO2.2)	Must start with Newton II NOT less force for same acceleration **Examiner's Comments** Few candidates identified that this question was about the implications of the equation F = ma. Candidates did not recognise that the force would be the same for both the heaver and the lighter model of car. Most candidates discussed the effects of friction on the car. For the order of magnitude for changes in mass between different models of a car frictional forces would have no measurable effect on acceleration. Exemplar 12  (i) Explain why the presenter is correct. If the car is heavier the to weight on the wheels can effect the acceleration. If the mass is less there will be less weight so the wheels so the acceleration will be better [2] This answer only considers the marginal changes in friction caused by a very small increase in the contact area of the tyres but ignores the more significant effect that the same force applied to a smaller mass will have on acceleration. Exemplar 13  (i) Explain why the presenter is correct. As force = mass x acceleration and force ÷ mass = acceleration a smaller mass with more force accelerates more BOD [2] This candidate's answer shows very clearly why using a more mathematical approach in physics saves time and increases understanding. They have identified the appropriate equation (F=ma), changed the

					subject to acceleration and then drawn the correct conclusion. Using this approach their answer was shorter, clearer and more relevant than exemplar 12.  **AfL** As a starter exercise show students the question and ask them to select the equation that will answer the question. Helping students to be more comfortable using equations will help them overcome their reluctance to answer physics questions using maths.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 5 (m/s^2) award 3 marks** change in speed = 25−5 = 20 (m/s) ✓ acceleration = 20 ÷ 4 (m/s^2) ✓ = 5 (m/s^2) ✓	3 (AO2.1) (AO2.1) (AO2.1)	e.c.f. incorrect change in speed if subtraction attempted **Examiner's Comments** This calculation was well done with most candidates being credited with all three marks.
			Total	**5**	
15	a		Distance (between source and observer) ✓ Time (for sound to travel between source and observer) ✓	**2 (AO 2 x 1.1)**	**Do not accept** distance / time the ball travels **Do not accept** metres / seconds **Examiner's Comments** Some candidates wrote a list of quantities that could be measured with no description: speed, distance, time, frequency and wavelength. These candidates could not be credited with any marks as they had not answered the question. Candidates were expected to describe how the distance that the sound would travel and the time for the sound to travel were needed to calculate the speed. Many candidates ignored the context for the question and referred to measuring the distance the ball travels.
	b		Speed = distance ÷ time ✓	**1 (AO 1.1)**	**ALLOW** distance ÷ time **Examiner's Comments** This question was answered well by candidates. Some candidates quoted the wave equation which was not appropriate to the experiment. A significant number of

					candidates incorrectly gave the correct equation as *speed = distance × time*..
	c		Takes several readings / take averages / increase distance ✓	**1 (AO 3.3a)**	**ALLOW** no wind **IGNORE** increase time **Examiner's Comments** Most candidates suggesting repeating the experiment and calculating an average. Some candidates suggested using different distances and then plotting a graph. Other candidates suggested increasing the distance to the observer.
			Total	**4**	
16			**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 12 (m/s) award 2 marks** Rearrange formula - 4 × 3 ✓ 12 (m/s) ✓	**2** **(AO 2.1)** **(AO 2.1)**	**Examiner's Comments** Higher ability candidates wrote out in a recognisable form that *change in velocity = acceleration × time = 3 × 4 = 12 (m/s)*. A common misconception was to divide the acceleration by time taken (i.e. 3 × 4 = 0.75). Candidates should be encouraged to put the numbers into the given equation which will help them to identify if they will need to rearrange the formula.
			Total	**2**	
17	a	i	50 (m) ✓	1 (AO2.2)	**Examiner's Comments** 16(a) was a gentle introduction to the structured questions in Section B and almost all candidates were awarded all three marks.
		ii	60 (s) ✓	1(AO2.2)	**Examiner's Comments** 16(a) was a gentle introduction to the structured questions in Section B and almost all candidates were awarded all three marks.
		iii	**Any one from:** Tape measure/ Measuring tape ✓ Trundle wheel ✓	1(AO1.1)	**ALLOW** Metre ruler / metre stick / metre wheel / surveyors' wheel **DO NOT ALLOW** ruler **ALLOW** Fitbit/smartphone app **Examiner's Comments** 16(a) was a gentle introduction to the structured questions in Section B and almost all candidates were awarded all three marks.
	b	i	C ✓ It has the steepest line/gradient/slope / greatest change in distance per second / AW ✓	2 (AO 2.2) (AO 1.1)	**ALLOW** calculation of all 4 speeds **NOT** 'highest distance change in shortest amount of time'

					Examiner's Comments 16(b) provided the first questions where more than one mark was available, and this helped a number who could identify the important factor but had selected the wrong option A – D. In (i) a number calculated all four speeds (including 0) in order to identify C. Most candidates appreciated that it was the section with the highest gradient/steepness which they needed to identify.
		ii	B ✓ The line is horizontal/flat /distance does **not** change/AW ✓	2 (AO 2.2) (AO 1.1)	**Examiner's Comments** 16(b) provided the first questions where more than one mark was available, and this helped a number who could identify the important factor but had selected the wrong option A – D. In (i) a number calculated all four speeds (including 0) in order to identify C. Most candidates appreciated that it was the section with the highest gradient/steepness which they needed to identify.
	c		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.5 (m/s^2) award 2 marks** v = 20 ÷ 40 ✓ v = 0.5 (m/s^2) ✓	2 (AO2.1) (AO2.1)	Mp2 dependent on correct substitution for mp1 **Examiner's Comments** The equation for acceleration was given and it required no rearrangement. Most candidates were credited with both marks here.
			Total	**9**	
18	a		Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** States that there is no clear trend. **AND** Detailed identification of at least two problems with the experiment with suggestions of detailed improvements.	6 (AO2×3.1a) (AO2×3.2a) (AO2×3.3b)	**AO3.1a Analyse information and ideas to describe trend in results** For example: • No obvious/discernible trend • As loads increased time ≈ the same • As loads increased speeds ≈ the same • 20N and 60N mean speeds the same • 20N and 60N times the same

			There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated. **Level 2 (3–4 marks)** Recognises that the average speeds are similar. **AND** Identifies at least one problem with the experiment with a suggested improvement. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Refers to data from the table. **AND** Suggests an improvement to the experiment or identifies one problem with the experiment. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*		• 40N and 80N mean speeds the same • 40N and 80N times the same **AO3.2a Analyse information and ideas to make judgements and identify problems with the experiment** For example: • Only 4 loads tested • Ramp distance too short • No repeated readings • Mass/weight of trolley ignored • Reaction times an issue for short times **AO3.3b Analyse information and ideas to improve experimental procedures** For example: • Test more loads • Include mass/weight of the trolley • Use a longer ramp • Have a smaller angle of ramp • Start higher up the ramp • Electronic timing method • Repeat readings and take a mean **<u>Examiner's Comments</u>** Because there was no systematic pattern in the data this was a demanding level of response question for a foundation tier candidates. Exemplar 5 is a candidate who scored Level 3, 6 marks for clearly identifying the absence of a trend and suggesting improvement to the experiment. Exemplar 6 is a Level 2 response, gaining 4 marks as the candidate has identified that the times and speeds are essentially similar and suggested improvements to the procedure. Exemplar 7 is a Level 1 response. The candidate makes reference to the data and makes a suggestion for doing a better experiment. This was judged to fit the Level 1 criteria exactly and was given 2 marks. **Exemplar 5**



21 A student investigates the average speed at which a trolley with different loads travels down a ramp.

Look at the diagram of her experiment.

She releases the trolley from a distance of 2.0m from the bottom of the ramp.

The student uses a stop-clock to measure the time it takes to reach the bottom of the ramp.

She calculates the average speed. Look at her results.

Load (N)	Time taken (s)	Average speed (m/s)
20	2.3	0.87
40	2.4	0.83
60	2.3	0.87
80	2.4	0.83

(a)* Describe the trend shown by the results, identify problems with the experiment and describe any improvements that you would make to the experiment.

There is no clear trend. When the speed is higher it takes less time to cover the distance. The problem is that the ramp is too short so time is not allowed for it to accelerate meaning that all speeds are extremely similar and a correlation is not shown between the load and speed. To improve she could make the ramp longer. She could experiment with different fixed angles in order to have a larger selection of results. If there was a bigger difference in the load, the may be able to see a clear trend. They are all too close in place. [6]

Exemplar 6

(a)* Describe the trend shown by the results, identify problems with the experiment and describe any improvements that you would make to the experiment.

Firstly, the table shows a trend, that the time taken at a similar average speed for example all the 2.30 have an average speed of 0.87m/s and 2.40 has an 0.83m/s.

The student could lean something up against the ramp to make sure it stays in a fix angle, the student could also instead use a light gate and not a stop watch to reduce human error and timing.

[6]

Exemplar 7

(a)* Describe the trend shown by the results, identify problems with the experiment and describe any improvements that you would make to the experiment.

- She could've done the experiment with the same load a few times to get a more accurate average speed
- When the load was 40N and 80N it was slower than 20N and 60N but the average speed was ~~fast~~ quicker.

	b		**EITHER** $v^2 - u^2 = 2as$ (no mark – on formula sheet) $u = 0$ ✓ $a = v^2 \div 2s$ ✓ $a = 2^2 \div (2 \times 2.0)$ ✓ $a = 1.0/1$ (m/s^2) ✓ **OR**	4 (AO2.1) (AO2.1) (AO2.1) (AO2.1)	If no working shown and answer = 1 (m/s^2), award all 4 marks. If wrong physics used, then award marks as appropriate for either approach. **Examiner's Comments** There were different possible approaches to the calculation: use of $v^2 = u^2 + 2as$ or finding the mean speed and hence t and using a =

			mean v = ½ (0 + 2 m/s) = 1 m/s ✓ $t = s$/mean v = 2 m / 1 m/s = 2 s ✓ $a = \Delta v/t$ ✓ = (2 m/s - 0)/2 s = 1 (m/s^2) ✓		(v-u)/t. Both were seen. Many candidates just randomly multiplied or divided the numbers given, and two of these operations gave a response of 1 m/s^2. Where candidates used incorrect physics in their response (e.g. acceleration = speed/distance = 2/2 = 1) then they only gained marks for those parts of their workings that were appropriate. For fairness candidates who only wrote '1' on the answer line with no workings shown were given the benefit of the doubt and awarded all 4 marks.
			Total	**10**	
19		i	(Driver under influence of) alcohol / drugs / tired / (named) distraction / ill / old-age / intoxication / high(er) speed ✓	1 (AO 1.1)	**IGNORE** just age **ALLOW** increase in driver's reaction time **Examiner's Comments** Many candidates correctly answered this question. The common factors were alcohol, drugs and tiredness. Some candidates did not score the mark for factors related to braking distances. Other candidates did not give an appropriate direction for the change, e.g. 'speed' was not credited but 'increasing speed' was credited.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 26 (m) award 2 marks** (Stopping distance =) braking (distance) + thinking (distance) OR 16 OR 10 ✓ (sd =) 26 (m) ✓	2 (AO 2×2.2)	**Examiner's Comments** The majority of the candidates gained one mark for correctly reading off either the thinking distance or the braking distance. Many candidates did not read the question carefully to realise it was the stopping distance that was required. Higher ability candidates clearly showed both the values from the graph and the addition.
			Total	**3**	
20			**Any two from:** Speed is a scalar ✓ Velocity is a vector ✓ Speed does not take direction into account / AW ✓ Velocity does take direction into account / AW ✓ Speed is calculated using distance ✓	2 (AO1.1 x 2)	

			Velocity is calculated using displacement ✓ Displacement depends on direction from start point / displacement takes into account direction ✓ Distance does not depend on direction from start point / distance does not take into account direction ✓		
			Total	**2**	