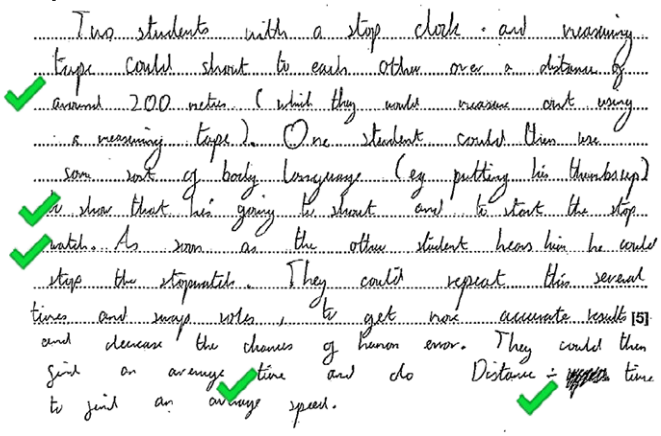
Mark scheme – Motion (H)

Question			Answer/Indicative content	Marks	Guidance
1			C ✓	1 (AO2.2)	**Examiner's Comments** About half of the candidates could correctly calculate the distance travelled from the graph (by area or calculation) and gave C as the answer. Working out was often seen on this question and answer D was a frequently chosen distractor (velocity × time, 8 × 5 = 40m).
			Total	**1**	
2			D ✓	1 (AO2.1)	**Examiner's Comments** About 40% of candidates gave the correct answer D. A common incorrect response (the differences in speeds rather than velocities with direction) was 'A'.
			Total	**1**	
3			B ✓	1 (AO2.1)	**Examiner's Comments** This was and intentionally challenging question AO2 question and about a quarter of candidates gave the correct answer B. A common incorrect response was 'D'.
			Total	**1**	
4			**C** ✓	1 (AO 1.1)	**Examiner's Comments** This question assessed candidates' knowledge of how the force of gravity can change the velocity of a planet but its speed stays the same. Most candidates correctly chose option C.
			Total	**1**	
5			B ✓	1 (AO2.1)	**Examiner's Comments** A very large number of candidates incorrectly chose A. Higher ability candidates worked out the area for each graph. Candidates should be encouraged to check each of the four responses.
			Total	**1**	
6			C ✓	1 (AO2.1)	**Examiner's Comments** This question was well answered. Candidates should be encouraged to consider each letter of

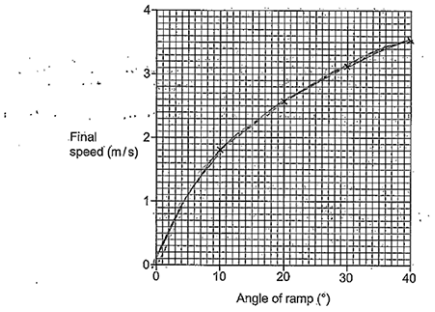
					the diagram, adding a small cross to the ones that are eliminated.
			Total	**1**	
7			**C** ✓	1 (AO2.1)	
			Total	**1**	
8			**B** ✓	1 (AO1.2)	
			Total	**1**	
9		i	initial speed is zero **and** • either acceleration due to gravity = 10 • or g = 10 ✓ use a = (v-u) ÷ t to find the final speed / v ✓ use $v^2 - u^2 = 2as$ to find s ✓	3 (AO 3 × 1.1)	**IGNORE** the idea of echoes and speed of sound **ALLOW** answers using g = 9.8 or 9.81 **ALLOW** v = u + at ✓ **ALLOW** credit for higher level answers: Eg. three marks for answer in terms of $s = ut + ½at^2$ **Examiner's Comments** This was an intentionally challenging question where less than 10% did not score at all. Most of these wrote about g = 10 and the initial velocity was 0 and gained 1 mark. Very few successfully continued further.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 22 (m/s) award 2 marks** 10 = v (- 0) / 2.2 OR uses idea that stone gains 10m/s each second ✓ V = 22 (m/s) ✓	2 (AO 2 × 2.1)	**ALLOW** 21.56 or 21.58 or 21.6 (if g=9.8 or 9.81) ✓✓ **Examiner's Comments** Again this challenging calculation saw about 1/5th gaining both marks with 22 (m/s). A few correctly used g = 9.8 or 9.81 and still scored full marks. Many used speed = distance ÷ time and did not score.
			Total	**5**	
10			(Idea of) action to produce sound and seen by observer / received by receiver ✓ Measure an appropriate distance eg between source and observer or between microphone(s) / speaker ✓ Measure an appropriate time eg between seeing action and hearing sound or on CRO / or	**5** (AO1.1) (AO2.2) (AO2.2)	**ALLOW** marks to be awarded from a clear diagram **ALLOW** higher level methods eg using standing waves **ALLOW** equation in any form **Examiner's Comments**

			frequency from signal generator ✓ (Idea of) calculating speed = distance / time or velocity = frequency x wavelength ✓ (Idea of) improvements to experiment eg repeat **and** average readings / retake readings if they are anomalous / use a different method / use different equipment / use longer distances ✓	(AO3.2b) (AO3.3b)	This question assessed AO1, AO2 and AO3 and discriminated well between the lower and higher ability candidates. Many correct experiments were suggested, for example practical improvements to the ball being hit by a bat making use of echoes, microphones and oscilloscope, as well as less practical suggestions in a school setting involving the use of fireworks and explosions. Some candidates made vague references to 'using a computer' that could not be credited. Most candidates realised that it was necessary to measure a time, but did not clearly specify what time they should measure. Almost every candidate gained some credit, many for stating the correct equation to calculate speed or for the idea of taking multiple readings and then using the average value. **Exemplar 2**  Two students with a stop clock and measuring tape could shout to each other over a distance of around 200 metres (whilst they make measurements and using a measuring tape). One student could then use some sort of body language (eg putting his thumbs up) to show that he's going to shout and to start the stop watch. As soon as the other student hears him he could stop the stopwatch. They could repeat this several times and many times, to get more accurate results [5] and decrease the chances of human error. They could then find an average time and do Distance ÷ time to find an average speed. This candidate gained full credit. The response included: • a suitable experiment • an appropriate time and distance measured • an equation to calculate the speed • the improvement of repeating and averaging the readings in order to improve accuracy and reduce the effect of operator error on their observations.
			Total	**5**	
11	a		E ✓ **FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 0.6 (s) award 2 marks** 5 ÷ 8 ✓ = 0.6 (s) ✓	**3** (AO3.1a) (AO1.2) (AO2.2)	**ALLOW** 0.625 or 0.63 (s) **Examiner's Comments** Most candidates were able to identify that driver E had the quickest reaction time. Only the higher ability candidates were then able to correctly calculate the reaction time. Calculations were sometimes shown and a common error made by candidates when calculating the reaction time was to use (*thinking distance + braking distance) ÷ speed*.

	b		Any two from: A, C or D ✓ Thinking distance / reaction time is proportional to speed / AW ✓	**2** (AO3.2b) (AO3.2b)	**ALLOW** as speed doubles, thinking distance doubles / ratio of speed:distance or distance:speed is the same / both have reaction time of 0.75 (s) **Examiner's Comments** This question required candidates to identify two drivers from A, C and D and explain why their reaction times are the same. Over half of the candidates correctly identified two of the drivers. Most of these candidates proceeded to explain why, usually by calculating the reaction time of 0.75 s. A significant number of candidates did not gain any credit. A common error candidates made was to choose drivers A and E or B and D due to their braking distances being almost the same.
	c	i	AWARD **ALL** CANDIDATES 2 MARKS	**2** (AO1 × 2.1) (AO1 × 1.2)	**Examiner's Comments** We have adjusted the mark scheme to allow for a typo within this question.
		ii	KE transferred to thermal energy / heat in brakes / surroundings / AW ✓✓ **OR** (KE of car) is reduced / transferred ✓ Brakes gain / absorb thermal energy / heat ✓	**2** (AO1.1) (AO1.2)	**ALLOW** surroundings gain thermal energy / heat dissipated to surroundings **IGNORE** just brakes get hot **Examiner's Comments** The majority of candidates knew that the kinetic energy store would decrease or be transferred and so were credited with one mark. Fewer candidates gained the second mark as although they referred to heat or thermal energy they did not specify that the energy was transferred to the brakes or surroundings (i.e. into a thermal energy store).
		iii	AWARD **ALL** CANDIDATES 3 MARKS	**3** (AO2 × 2.1) (AO1.2)	
			Total	**12**	
12		i	16 (m) ✓	1 (AO 3.1a)	

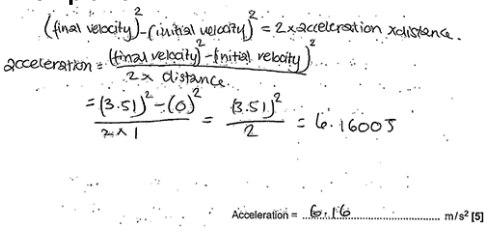
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.67 (s) award 3 marks** Rearrangement to give Time = distance / speed ✓ Time = 16 / 24 #x2713; Time = 0.67 (s) (2 decimal places) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	**ALLOW** ECF from **(b)(i)** **ALLOW** 0.6 or 0.7 or 0.66(6…) (s) for 2 marks **ALLOW** one mark for any calculated answer to 2dp **Examiner's Comments** There were many excellent responses for this question with the majority of candidates gaining full credit. A few candidates could not rearrange the equation correctly and therefore did not score any marks. About one fifth of candidates did not give their answers to 2 decimal places as requested. **AfL** A number of candidates gave two possible versions of rearranging the equation leading to two different answers. Candidates should be aware that marks cannot be awarded when they do this, even if one of the versions is correct. **Exemplar 1** (ii) Calculate the **thinking time** at 24 m/s. Use your answer to **(b)(i)** and the equation: distance travelled = speed × time Give your answer to 2 decimal places. thinking time = distance / speed = 16 m / 24 m/s = 0.666... = 0.67 Thinking time = 0.67 s [3] This is an excellent example of how the response should be set out. The candidate has clearly rearranged the equation, before substituting the correct values for distance and speed and writing down the answer. This would allow compensatory marks to be awarded if the candidate had then made an error such as mis-entered numbers into the calculator. Finally, the candidate has underlined the instruction to give their answer to 2 decimal places so that they do not forget to do this.
			Total	**4**	
13		i	Area (under line) for thinking (distance) is same as for braking (distance) / area under horizontal line = area under diagonal line / area of rectangle = area of triangle / AW ✓	1 (AO 3.1a)	**ALLOW** both areas show 4(m) **Examiner's Comments** This question was a good discriminator as only the more able candidates recognised that the braking distance and thinking distance could be calculated from the area under the graph and that both had the same value.

		ii	A line starting at (0.75, 8) ✓ Diagonal line drawn parallel to original line and finishing at the x axis ✓	2 (AO 2×1.2)	Mark independently
			Total	**3**	
14		i	Mean = (0.28 + 0.32) = 0.30 (s) ✓	1 (AO 1.2)	**ALLOW** 0.3 (s) **DO NOT ALLOW** answers with all 3 readings used giving a mean of (0.28+0.32+0.54) / 3 = 0.38 (s) **Examiner's Comments** **AfL** Candidates need to be aware that anomalous readings in a set of results, due to a mistake or lack of attention, are not included in calculations of the mean.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 333 (m/s) award 4 marks** Use of distance = 100 m ✓ Recall (s =) d / t ✓ 100 / 0.3 ✓ (s =) 333 (m/s) (3 sig. figs.)✓	4 (AO 2.1) (AO 1.2) (AO 2.1) (AO 2.1)	**ALLOW ECF** from **24(a)(i)** **ALLOW** 100 ÷ 0.38 ✓✓✓ **ALLOW** 263 (m/s) ✓✓✓✓ **ALLOW** ECF for 3rd and 4th marking points if incorrect distance is used **ALLOW** 50 ÷ 0.3 or 166.7 ✓✓ **ALLOW** 50 ÷ 0.38 or 131.6 ✓✓ **ALLOW** 132 ✓✓✓ **ALLOW** 167 ✓✓✓ **Examiner's Comments** The majority of candidates could rearrange the equation provided, substitute values and give their answer to 3 significant figures. However, many candidates did not take into account that the sound travelled 100m to the wall and back again so used 50m in their calculations instead. **AfL** A number of candidates gave two possible versions of rearranging the equation leading to two different answers. Candidates should be aware that marks cannot be awarded when they do this, even if one of the versions is correct.

		iii	**Any two from:** Inconsistent results should be repeated ✓ More readings of time should be done and the mean calculated ✓ (Explanation of) clap-echo method ✓ Larger/different distances used ✓	2 (AO 2×3.3b)	Clap-echo method effectively may gain 2 marks as it also uses the idea of multiple readings. **Examiner's Comments** This Assessment Objective 3 question required candidates to analyse information in order to develop the experimental procedure of the students (in Question 24(a)). There is evidence that over half of the candidates did not read the question carefully as they suggested improvements relating to other methods such as videoing, using microphones etc. Many candidates suggested taking more readings but did not mention calculating the mean and therefore could not score the mark.
			Total	**7**	
15	a	i	Both points correctly plotted ✓ Smooth curve correctly drawn ✓	2 (AO1.2)	**ALLOW** within ½ small square for plotting **DO NOT ALLOW** straight lines between data points **IGNORE** any line drawn for <10° **Examiner's Comments** Candidates needed to plot the last two data points before drawing the best fit line. Many candidates incorrectly drew a straight line through plots that appeared to lie on a curved trend. Other candidates did not draw smooth curves, or had many lines. **Exemplar 5**  This candidate has clearly indicated the correct positions of the two missing plots using two small crosses. The smooth line was not considered good enough in that there appeared to be more than one line in several places. This candidate has correctly assumed that the graph starts from the origin.

					 **AfL** Candidates should be encouraged to plot graphs using a sharp pencil. The points should be indicated with a small cross. It may help candidates to draw smooth curves by rotating the paper so that the curve can be drawn naturally with the arc of the candidates' arm. Candidates should be encouraged to check the plotting of their data points - particularly points which do not appear to fit a pattern. The line of best fit may not pass through every data point. There should be a balance of data points about the line of best fit.
		ii	Increase in angle of ramp increases speed (at bottom ramp) ORA✓ Increase is not linear/doubling angle does not double final speed / AW ✓ Reference to quantitative data for two calculations, for example, increase from 10˚ to 20˚ the speed increases by 0.76 whilst 20˚ to 30˚ the speed increases by 0.54 ✓	3 (AO3.1a) (AO3.1a) (AO3.1b)	**IGNORE** correlation ALLOW Not directly proportional / Not constant increase **NOTE comparison of two increases required** **NOTE** Speed increase from 0˚ to 10˚ is 1.81 and speed increase from 30˚ to 40˚ is 0.40 **<u>Examiner's Comments</u>** Most candidates correctly stated that the as the angle of the ramp increased the speed increased. It was essential that candidates included a comparison between the angle of the ramp and the speed. The next two marks were more challenging and required candidates to state that the angle of the ramp and the speed were not directly proportional or linear since there was not a constant increase in speed for the same increase in angle. Candidates were expected to demonstrate this by carrying out two calculations using data from the table or graph.  **AfL** Understand how to test from a graph whether two quantities are directly proportional. 1. Take the quantity on the x-axis and double it and read off the y-axis values and see whether they double as well 2. See whether there is a straight line through the origin.

		iii	(Increase in angle) increases potential energy of the trolley/more work is done raising trolley to that point on the ramp ✓ This **increases** the / **more** kinetic energy at the bottom of the ramp ✓	2 (AO1.1 x2)	**ALLOW more** PE is transferred to KE **Examiner's Comments** Most candidates found this question challenging to gain two marks due to some vague answers relating to the transfer energy from the PE store to the KE store without specifically referring to the greater energy in the PE store being transferred so that there more energy in the KE store.
		iv	Attempt 1 at 30˚ (is only recorded to 1 decimal place)/ 3.1 ✓ Student should record data to a consistent number of decimal places or 2 dp / the reading should by recorded as 3.10 / AW ✓	2 (AO3.3a) (AO3.3b)	**ALLOW** only recorded to 2 significant figures **ALLOW** should be recorded to 3 significant figures **NOT** same accuracy **Examiner's Comments** Many candidates correctly identified that the first attempt (3.1) at an angle of 30° was only recorded to one decimal place. Most candidates then suggested that that the raw data should have been recorded to the same number of decimal places and the reading should have been recorded as 3.10. Some candidates referred to significant figures, which was allowed this year. Candidates need to understand that raw data should be recorded to the same number of decimal places while calculated data is recorded to a number of significant figures which is dependent on the number of significant figures in the raw data.
		v	**Any two from:** Reproducible means that the results can be reproduced by someone else ✓ Only one student has collected this data ✓ The experiment is repeatable (as the repeated readings are close together) ✓	2 (AO2.2 x2)	**NOT** experiment can be repeated **Examiner's Comments** Most candidates discussed apparatus details such as not indicating what sort of surface was used, etc. Few candidates realised that reproducible results would need to be reproduced by someone else. A few candidates did state that the experiment is repeatable since the repeated reading are close to each other.  **AfL** Understand the terms used in the language of measurement. See the Glossary of terms on the OCR website at:

					https:/www.ocr.org.uk/Images/467774-glossary-of-terms.doc
	b	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 6.16 (m/s^2) award 5 marks** $v^2 - u^2 = 2as$ (no mark – on formula sheet) $u = 0$ ✓ $a = v^2 \div 2s$ ✓ $a = 3.51^2 \div (2x1.0)$ ✓ $a = 6.16005$ (m/s^2) ✓ $a = 6.16$ (m/s^2) (2 decimal places) ✓	5 (AO2.1) (AO1.2) (AO2.1) (AO2.1) (AO1.2)	NOTE must be rearranged **ALLOW** Any number which rounds to 6.16 **ALLOW** one mark for any calculated answer to 2dp **Examiner's Comments** About half the candidates gained full marks for this question. It was expected that candidates would select an appropriate equation from the data sheet, rearrange the equation and substitute in the numbers from the question before calculating the answer. It was expected that the initial speed of zero would be shown in any calculation. Many candidates who did not gain full marks attempted to gain the answer by using the definition of acceleration and the equation linking average speed with distance and time without realising the importance of the word "average". Candidates using this method often arrived with an incorrect answer of 12.32 m / s^2. **Exemplar 6**  This candidate has correctly selected the equation from data sheet. The candidate has then rearranged the equation before substituting in the values form the question. Helpfully the candidate has indicated that the initial velocity was zero. The candidate then correctly calculates the answer as 6.16005 before correctly rounding the answer to two decimal places.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 9 (J) award 3 marks** kinetic energy (J) = 0.5 x mass	3	**Examiner's Comments** Candidates who were able to recall the equation for kinetic energy scored well on this question. Candidates should be encouraged to show their working.

			(kg) x (speed (m/s))^2 / KE = ½ mv^2 / KE = 0.5mv^2 ✓ KE = 0.5 x 2.0 x 3.0^2 ✓ KE = 9 (J) ✓	(AO1.2) (AO2.1) (AO2.1)	
			Total	**19**	
16			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 explanation about why speed and velocity are different from each other **AND** Calculations of speed **and** velocity completed and are correct *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)** Detailed explanation about why speed and velocity are different from each other **AND** Calculation of speed **OR** velocity completed and is correct **OR** both equations stated/implied **OR** Explanation about why speed and velocity are different from each other **AND** Calculations of speed **and** velocity completed and are correct *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)** Explanation about why speed and velocity are different from	6 (AO1.1x4) (AO2.1x2)	**AO1.1 Demonstrate knowledge and understanding of the difference between speed and velocity** For example: • speed is a scalar • velocity is a vector • speed has magnitude only • velocity has magnitude and direction • speed depends on distance • velocity depends on displacement • speed is rate of change of distance • velocity is rate of change of displacement **AO1.2 Recall of speed and velocity equations** • speed = distance / time • velocity = displacement / time **AO2.1 Apply knowledge and understanding of calculating speed and velocity** For example: • speed = 3.0 / (0.5x60) • speed = 0.10 (m/s) • velocity = 0.6 / (0.5x60) • velocity = 0.02 (m/s)

			each other. **OR** Calculation of speed **or** velocity completed and is correct **OR** Both equations stated/implied *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.		
			Total	**6**	
17			**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 8 (m/s) award 4 marks** u = 0 **or** $v^2 = (u^2 +) 2as$ ✓ $v^2 = 2 \times 10 \times 3.2$ or $v = \sqrt{(2 \times 10 \times 3.2)}$ ✓ $v^2 = 64$ ✓ v = 8 (m/s) ✓ **OR alternative method:** $mgh = ½ mv^2$ ✓ $(70 x) 10 \times 3.2 = ½ (\times 70) \times v^2$ ✓ $64 = v^2$ ✓ v = 8 (m/s) ✓	4 (AO1.2) (AO2.1) (AO2.1) (AO2.1)	$v^2 - u^2 = 2as$ does not score a mark
			Total	**4**	
18	a		(All galaxies) showed <u>red-shift</u> ✓ (Hubble measured the) wavelength/frequency of <u>light</u> (from the galaxy) ✓	2 (AO2 × 1.1)	**ALLOW** (all galaxies) showed <u>light</u> with a longer wavelength/lower frequency for 2 marks
	b	i	Readings of speed taken for two different values of distance ✓ Working to show that the factor increase in speed is the same as distance ✓	2 (AO2 × 3.1a)	**ALLOW** +/- ½ a small square **ALLOW** a statement for the second mark e.g. as the distance doubles so does the speed. <u>Example:</u> At 20 Mpc, speed = 1400 km/s At 40 Mpc, speed = 2800 km/s 40/20 = 2 = 2800/1400 **ALLOW** 1 mark maximum for it is a (straight) line of best fit through the origin (therefore it is proportional)

		ii	**Any one from:** The more distant galaxies are travelling faster ✓ The evidence suggests the universe is expanding ✓ The universe was smaller in the past ✓	1 (AO1.1)	**ALLOW** galaxies are moving away from each other
	c		To ensure results are reproducible / check the work is of high enough quality / claims are not false / for new theories to be accepted / to develop theories / AW ✓	1 (AO1.1)	**ALLOW** check validity / for mistakes/anomalies / AW **ALLOW** check that it's not biased / AW
	d	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 5 800 000 (m/s) award 2 marks** (Reads off speed from graph =) 5800 (km/s) ✓ Speed = 5800 × 1000 = 5 800 000 (m/s) ✓	2 (AO2.2) (AO1.2)	**ALLOW** 5.8×10^6 (m/s) **ALLOW** ecf for their speed from graph x 1000
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 4.36×10^{17} (s) award 3 marks** time = distance / speed ✓ (time =) 2.53×10^{24} / 5 800 000 ✓ (time =) 4.36×10^{17} (s) ✓	3 (AO1.2) (AO2.1) (AO2.1)	**ALLOW** ecf from **(i)** **ALLOW** 4.4×10^{17} (s) **ALLOW** equation in any form
			Total	**11**	