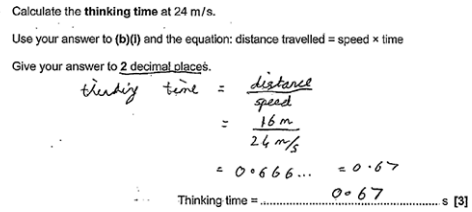
Mark scheme – Physics on the Move (H)

Question	Answer/Indicative content	Marks	Guidance
1	**B** ✓	1 (AO1.2)	
	Total	**1**	
2	**B** ✓	1 (AO 1.1)	**Examiner's Comments** Candidates are expected to be able to recall typical speeds such as cycling, wind and sound. Most candidates were able to do this successfully.
	Total	**1**	
3	**C** ✓	**1 (AO2.2)**	**Examiner's Comments** Many candidates struggled to estimate the force of the brakes, often incorrectly choosing distractor B. Those candidates who correctly choose distractor C were often seen to write down their estimated values of the mass and acceleration. **AfL** Candidates would benefit from being provided with opportunities to estimate, the speed, accelerations and forces involved for everyday road transport.
	Total	**1**	
4	**B** ✓	**1 (AO1.1)**	**Examiner's Comments** This question required candidates to recall and apply the equation: *acceleration = change in velocity ÷ time* as well as use the relationship provided to convert m/s into mph. Most candidates were able to do this successfully.
	Total	**1**	
5	**D** ✓	**1 (AO1.2)**	
	Total	**1**	

6			F ✓	**1** (AO3.3a)	**Examiner's Comments** Almost all candidates were able to answer this correctly.
			Total	**1**	
7	a		Correct reference or attempt to use area under sloping part of graph (1) $\frac{8 \times 1.5}{2} = 6$ (1)	2	**ALLOW** full marks for correct calculation as this implies correct use of area under sloping part of graph.
	b		<table><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td>(32)</td><td>24</td><td>**96** (1)</td><td>**120** (1)</td></tr></table>	2	
			Total	**4**	
8	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		(The **thinking** distance will) **stay the same** (The **braking** distance will) **decrease** (The **stopping** distance will) **decrease** **All three** correct ✓✓ **Two** correct ✓	**2** (AO3.2b) (AO3.2b)	**Examiner's Comments** Higher ability candidates generally were credited with full marks for this question. However a third of the candidates did not provide any creditable response. . **AfL** These 'thought experiment' type questions can be used as short starter activities to help students develop the habit of thinking about science. Candidates can also be encouraged to quickly sketch out the question. This can help candidates to visualise how the forces acting on the car have changed from moving along the flat road to moving uphill at a constant speed.
			Total	**7**	
9	a	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.
	b		As speed increases, (thinking) distance increases / ORA ✓ **BUT** (thinking) distance is (directly) proportional to speed / as speed doubles, (thinking) distance doubles / linear relationship through the origin ✓✓	2 (AO 3.1a) (AO 3.2b)	**ALLOW** numerical values from graph, e.g. at 15 (m/s), td = 10m but at 30 (m/s) td = 20(m). **ALLOW** numerical values from graph, e.g. at 15 (m/s), td = 10 (m) but at 30 (m/s) td = 2×10 = 20 (m) for 2 marks **Examiner's Comments** This AO3 question assessed candidates' ability to interpret the distance-speed graph and draw conclusions about how thinking distance varies with increasing speed. The question discriminated well. Most candidates were able to give a basic description that as speed increases, thinking distance increases but only the more able candidates were able to give a more detailed relationship, e.g. speed is proportional to thinking distance, for 2 marks.

	c		**Maximum 2 marks from:** Higher speed increases braking distance ✓ **BUT** Double speed quadruples braking distance / braking distance is (directly) proportional to the speed squared AW ✓✓ **Maximum 2 marks from:** (Idea that) higher speed (car has) more KE ✓ **BUT** Double speed quadruples KE / KE is (directly) proportional to the speed squared / AW ✓✓	3 (AO 2.1) (AO 3.1ax2) (AO 2.1) (AO 3.1ax2)	**ALLOW** numerical values from graph, e.g. at 10 (m/s), bd = 7.5 (m) but at 20 (m/s) bd = 30 (m). **ALLOW** numerical values from graph, e.g. at 10 (m/s), bd = 7.5 (m) but at 20 (m/s) bd = 4×7.5 (= 30m) for 2 marks **Examiner's Comments** This question covered Assessment Objectives 2 and 3 and assessed candidates' ability to apply their knowledge of kinetic energy and braking distance as well as to interpret the graph. The majority of candidates scored 2 marks for linking a higher speed to increased kinetic energy and braking distance. Although some candidates recognised that the relationships were linked to a 'square factor' they could not express it clearly and therefore only the more able candidates gained full credit for recognising that speed is directly proportional to kinetic energy and/or braking distance.
	d	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** Although the majority of candidates answered this question correctly, candidates should be aware that vague answers such as 'speed' or 'age' without any qualification will not gain credit.
		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** This question assessed candidates' ability to read the values of thinking distance and braking distance from the distance-speed graph. Most candidates scored 1 mark for reading at least 1 value correctly but many did not calculate the stopping distance by adding the thinking distance and braking distance together, with some multiplying or subtracting the values instead.
			Total	**12**	
10	a	i	(Store of) KE (in moving car) ✓ (transferred thermally)	2 (AO 2×2.1)	**Examiner's Comments**

			to (store of) thermal energy / heat (in brakes/pads/discs/tyres) ✓		This question assessed candidates' ability to apply their knowledge of energy stores. Most candidates scored at least 1 mark for identifying either kinetic energy or thermal energy but it was generally only the more able candidates that identified both energy stores correctly.
		ii	**Any one from:** (Idea of) heat dissipated/transferred (to air) more quickly ✓ KE is reduced more quickly ✓	1 (AO 2.1)	**IGNORE** to thermal energy of road/surroundings **Examiner's Comments** It was evident that most candidates found this question very challenging, with usually only the most able gaining 1 mark.
	b	i	(Idea of measuring) a length/distance on the ruler ✓	1 (AO 1.2)	**Examiner's Comments** The majority of candidates gave a correct response but it was also common to see incorrect explanations referring to using a stopwatch to time how long it took driver Q to catch the ruler.
		ii	**Any one from:** drop ruler from same height above hand ✓ (idea of) change the time taken before dropping the ruler each time ✓ make sure hand of catcher not moving / fingers are the same distance apart ✓	1 (AO 1.2)	**ALLOW** suitable answers that refer to reducing named random or systematic errors e.g. measure from same place on the ruler (relative to hand) **ALLOW** (idea of driver Q being) unaware of when ruler is being dropped **ALLOW** repeat and calculate mean
	c	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	**8**	