Question	Answer	Marks	Guidance
1 a	9.8 (m) or $\frac{1}{2}$ x 14 x 1.4 (2) **but if incorrect allow** attempt at calculating area under the graph (1)	2	 **Eg** shown on graph by shading / AW [1] **If no other marks scored then allow** 14 x 1.4 or 19.6 [1]
b i	instantaneous deceleration at point P is (more representative of) when diver enters water [1] idea of ignoring anomalous results / point Q is not on the line / (1) Elaine's method covers more data / more appropriate data / AW [1] (gradient gives a more) accurate result (1)	2	**allow** Q is (some time) after diver enters water [1] allow deceleration / acceleration changes (after P) [1] **eg** point Q is anomalous [1]
b ii	1200 (N) (1)	1	**Allow** -1200 (N) [1]
	Total	**5**	

Question	Answer	Marks	Guidance
2 a	**7** minutes scores [3] **but if answer incorrect or incomplete then:** $\frac{1{,}680{,}000 \times 2}{8{,}000}$ or 420 scores [2] **but if no marks scored then:** either use of correct average speed, 4000 or 210 or 3.5 minutes scores [1]	3	7 **seconds** scores [2] **Ignore** units
b i	**lower speed** (than 8000m/s) then: - centripetal / gravitational force too high (to stay in this orbit) [1] - rocket may fall / move or spiral to Earth [1] **higher speed** (than 8000m/s) then: - centripetal / gravitational force too low (to stay in this orbit) [1] - rocket may move away from Earth / spiral out of orbit [1] (idea of) higher stable orbits experience lower gravitational force or lower speed / ORA [1]	3	**Eg.** rocket may fall as centripetal / gravitational force is too big [2] **eg.** rocket may move away as centripetal / gravitational force is too small [2] **allow** any idea that correct speed needed to allow correct angle of re-entry to avoid overheating [1]

Question	Answer	Marks	Guidance
ii	(+/-) 4 (m/s^2) scores [3] **but if answer is incorrect then:** (+/-) $\frac{(120^2 - 2000^2)}{2 \times 5 \times 10^5}$ [2] **Or if no other marks scored then** evidence of correct substitution into $v^2 = u^2 + 2as$ **or** evidence of **rearranged** formula: $\frac{v^2 - u^2}{2s}$ [1]	3	**allow** 3.99 / 3.9856 (m/s^2) [3]
c i	share expertise / knowledge / data / workload interpretations of evidence [1] check / test / compare (each other's) results [1]	1	**Eg.** work / ideas can be shared [1] **Eg.** more data collected [1] **Eg.** more / different jobs can be done (at same time) [1] **Eg**. Idea of international collaboration / sharing cost [1]
ii	other scientists can check or test or verify findings / develop ideas or theories / use or compare the data / improve knowledge or education / more data available / credit or acknowledgement of work [1]	1	**allow** (idea of) peer review [1]
	Total	**11**	

Question	Answer	Marks	Guidance
3 a	1.25 (m/s) (2) **but if answer is incorrect** $\frac{1000}{800}$ (1)	2	 **ignore** $\frac{500}{400}$ as this is incorrect from the graph
b	2 (m/s) (2) **but if answer is incorrect** $\frac{500}{250}$ (1)	2	 tolerance of 500/240 =2.1 to 500/260 = 1.9 mark to 1 decimal place
	Total	4	

Question	Answer	Marks	Guidance
4 a	11.25 m (3) **but if incorrect** 56.25 = 5 x h (2) **but if incorrect** KE = ½ x 0.5 x 15 x 15 (1) **or** m g h = ½ m v^2 / PE = KE (1)	3	 **allow** 56 = 5h (2) 11.25 (3) **if incorrect** time = 1.5 (seconds)(1) average speed = 7.5 (1) **allow** other correct calculations using equations of motion
b	**any one from** (idea that the) mass cancels out on the equation (1) (idea that without air resistance) both masses have the same acceleration (and so reach the same speed in the same time) (1)	1	
	Total	**4**	

Question	Answer	Marks	Guidance
5 a	Maximum range (achieved) at 45^0 [1] **BUT** Range rises with angle until 45^0 then falls [2]	2	**Ignore** references to height eg 'the further away from 45^0 the lower the range scores' [2] **if no marks awarded:** **allow EITHER** 'rises and falls' **OR** 'as the angle increases the range decreases' [1] eg 'range goes up and then goes down' [1]
b	90^0 [1]	1	**allow** vertical / AW [1] **allow** suitable annotation of the diagram
c i	Parabolic / parabola [1]	1	**ignore** curve / arc / arch on its own **ignore** trajectory
ii	(Vertical / upward) velocity decreases [1] Acceleration (remains) constant / AW [1]	2	Mark points independently: eg. vertical velocity and acceleration are reduced for a maximum of [1] eg. vertical velocity and acceleration are constant for a maximum of [1]
iii	no effect (by gravity) / AW [1]	1	**Allow** doesn't (change) [1] **Allow** (Stays) constant [1]
	Total	**7**	

Question			Answer	Marks	Guidance
6			**Level 3** Answers must refer accurately to all the relative distances travelled in each 2 second period. Also the correct accelerations must be given. A good cover of all aspects of the scenario in the question is needed for 5-6 marks. Quality of written communication does not impede communication of the science at this level. **(5–6 marks)** **Level 2** Answers refer to the accurate and relative accelerations for each 2 second period **OR** the correct distances travelled. Quality of written communication partly impedes communication of the science at this level. **(3–4 marks)** **Level 1** Answers are limited to correct relative accelerations which may be related to the steepness of the gradients. It may not refer to time at all. Quality of written communication impedes communication of the science at this level. **(1–2 marks)** **Level 0** Insufficient or irrelevant science. Answer not worthy of credit. **(0 marks)**	6	**This question is targeted up to grade A*** **Indicative scientific points may include** **Level 3:** • 4m in 1st 2s, 8m then 14m • **and** 2 (m/s^2), then zero acceleration or steady speed, then 3 (m/s^2) **Level 2:** • 4m in 1st 2s, 8m then 14m • **or** 2 (m/s^2), then zero acceleration or steady speed, then 3 (m/s^2) **Level 1:** • correct relative accelerations which may be related to the steepness of the gradients • low acceleration, then no acceleration then higher acceleration Use L1, L2, L3 annotations in scoris; do not use ticks.
			Total	**6**	

Question			answer	Marks	Guidance
7	(a		cruising speed = 10 (m/s) (2) **but if answer is incorrect** 30 = (v/2) x 6 **or** (2 x 30) ÷ 6 or 60 ÷ 6 (1) **then** if a correct calculation is given: Samuel / he is not correct (it is twice as fast) (1)	3	If answer says that cruising speed = 30 / 6 = 5 **AND** that Sam is correct (1). **OR** **allow** Samuel has calculated the **average speed** (5m/s) (1)
	(b)		between 0 and X is longer time than between Y and Z / AW / ORA (1) between 0 and X is lower acceleration than between Y and Z / AW / ORA (1) between 0 and X is acceleration but between Y and Z is deceleration or negative acceleration (1)	2	**allow** it is getting faster between O and X **but** slower between Y and Z (1) **ignore** just acceleration between Y and Z. **ignore** 'faster' acceleration / deceleration **allow** correct calculations to illustrate the marking points. Eg. 10/6 (1.67) compared to 10/2 (-5) (2) **allow** ecf for a correct calculation. Eg. 5/6 (0.83) compared to 5/2 (-2.5) (2) **allow** deceleration is 3 times greater / AW (2)

Question			Answer	Marks	Guidance
	(c)	(i)	108000 (W) (2) **but if answer is incorrect** (6000 + {8 x 600}) x 10 or (6000 + 4800) x 10 or 10800 x 10 (1)	2	**allow** ecf for incorrect cruising speed in 1(a)
		(ii)	1100 (kg) (2) **but if answer is incorrect** (6000 + {8 x 600}) ÷ 9.8 or (6000 + 4800) ÷ 9.8 or 10800 ÷ 9.8 (1)	2	1102.(0408) (1)
			Total	**9**	

Question			Answer	Marks	Guidance
8	(a)		30 (m/s) scores (2) **but if answer is incorrect** 75 ÷ (0.5 x 5) or 150 ÷ 5 scores or 75 ÷ 2.5 (1)	2	
	(b)		**any two from:** braking may not (always) leave a skid mark (1) (more or less) tread may affect skidding / AW (1) wet / icy / slippy road (may affect friction) (1) (more / less) weight of / load in car (1) (so) length of skid mark is not the same as braking distance (1)	2	eg ABS brakes may not leave a skid mark (1) eg Non ABS cars may skid more (1) **but** some cars have ABS (0) **allow** may have started braking before he skidded (1) **ignore** references to reaction (time / distance) **ignore** road and brake conditions unless qualified eg Worn brakes / bad road conditions (0)
	(c)	(i)	(KE) doubles (with double the mass) / AW (1)	1	
		(ii)	(KE) quadruples / AW (1)	1	
		(iii)	braking distance quadruples / AW (1)	1	
			Total	**7**	

Question			Answer	Marks	Guidance
9	(a)		yes (no mark) **A** is a positive gradient or slope but **C** and **D** are negative gradient or slope [1] **D** is higher / steeper gradient or slope (than **C**) [1]	2	**allow A** is a line going up and **C** is a line going down **allow** illustrative calculations from graph in either response eg accelerations : **A** 2.5/40 / 0.625 **C** -0.5/40 / -0.0125 **D** -2/100 / -0.020 (units not needed) [2] eg if correct values for **C** and **D** given with no minus sign [1] **allow** correct descriptions in either response eg speed or values increasing in **A** but decreasing in **C** / AW or graph goes up in **A** but down in **C** / AW [1] speed decreasing more rapidly in **D** than **C** / AW or graph goes down more rapidly in **D** compared to **C** / AW [1]
	(b)	(	50m [1]	1	if no answer is ringed or otherwise indicated **allow a** written answer of 50m in answer space no working mark
		(ii)	667 (s) [2] **but if answer is incorrect** 1200 ÷ 1.8 or 666.666 or 666.667[1]	2	**allow** 666 [1] **allow** time **=** distance ÷ speed or 1.2 ÷ 1.8 [1]
			Total	**5**	

Question	Answer	Marks	Guidance
10	**[Level 3]** **Describes how KE changes in both sections AND describes how GPE changes in both sections** **AND calculates the maximum KE or difference in height.** Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **[Level 2]** **Describes how KE AND how GPE changes for both sections** **OR describes correctly how KE changes over both sections and calculates maximum KE** **OR describes correctly how GPE changes over both sections and calculates maximum KE** **OR calculates difference in height.** Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **[Level 1]** **Realises that KE depends on speed and describes changes over part of journey** **OR describes how GPE changes over part of journey** **OR attempts to calculate maximum KE /height** **OR loss in KE = gain in PE (on either section)** **ORA** Quality of written communication impedes communication of the science at this level.(1-2 marks) **[Level 0]** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted at grades up to A*** **Ignore points after C** **Indicative scientific points at all levels may include:** • KE increases from **A** to **B** • KE decreases from **B** to **C** • GPE decreases from **A** to **B** • GPE increases from **B** to **C** • loss in GPE = gain in KE • KE = $\frac{1}{2}mv^2$ • maximum KE = 51200J • GPE = mgh • 51200 = mgh = 400 x10 x h • height = 12.8m **Use the L1, L2, L3 annotations in Scoris; do not use ticks.**
	Total	**6**	

Question	Answer	Marks	Guidance
11	**(Level 3)** **calculates the force** **AND** **Gives a detailed linked answer in terms of forces or acceleration** Quality of written communication does not impede communication of the science at this level (5 – 6 marks) **(Level 2)** **calculates the force** **AND** **Gives a simplistic answer in terms of forces or acceleration** Quality of written communication partly impedes communication of the science at this level (3 – 4 marks) **(Level 1)** **calculates the force** **OR** **Gives a simplistic answer in terms of forces or acceleration** Quality of written communication impedes communication of the science at this level (1 – 2 marks) **(Level 0)** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted up grade C** **Indicative scientific points at level 3 may include:** **The calculation from level 1 and 2 and a link between change in distance or stopping time to acceleration or force.** • increases distance travelled by dummy so this reduces force / acceleration of dummy • increase stopping time of dummy so this reduces force / acceleration of dummy • reduced acceleration so reduced force • reduces the rate of change of momentum • **Indicative scientific points at level 1 and 2 may include:** • force = 28020 or 28000 N **seatbelts** • hold dummy in seat / stop dummy hitting windscreen • stretches • reduce forces on dummy • increase stopping time of dummy • decrease acceleration of dummy **Use the L1, L2, L3 annotations in Scoris; do not use ticks.**
	Total	**6**	