2	**The only correct answer is C (initial acceleration is same for coin and feather, and time taken to reach the ground is less for coin)** A is not correct because both objects have the same initial acceleration B is not correct because both objects have the same initial acceleration and object A has a greater terminal velocity D is not correct because object A has a greater terminal velocity	1

5	**C 0.850 m**	1
	Incorrect Answers: a metre rule measures to 3 sf so the final answer must be to 3 sf regardless of the units used A – answer to 2 sf in cm B – answer to 2 sf in m D – answer to 2 sf in m (using standard form)	

8	**The only correct answer is D** (-9.8 m s^{-1}) A is not correct because the ball is in freefall so has acceleration due to gravity B is not correct because the ball is in freefall so has acceleration due to gravity C is not correct because the ball is in freefall so has acceleration due to gravity	1

7	**A is the correct answer** B is incorrect because the distance has not been doubled and the time has not been squared C is incorrect because the distance is in the wrong unit D is incorrect because the distance is in the wrong unit, has not been doubled and the time has not been squared	1

4	**4. The only correct answer is C** ***A*** *is not correct as* $u\cos\theta$, *the horizontal and not the vertical component of the initial velocity was used in the equation* $a = \frac{v-u}{t}$ ***B*** *is not correct as* $u\cos\theta$, *the horizontal and not the vertical component of the initial velocity was used in the equation* $a = \frac{v-u}{t}$ *and the negative sign implies that u and a are in the same, and not opposite directions.* ***D*** *is not correct as the negative sign implies that u and a are in the same, and not opposite directions.*	(1)

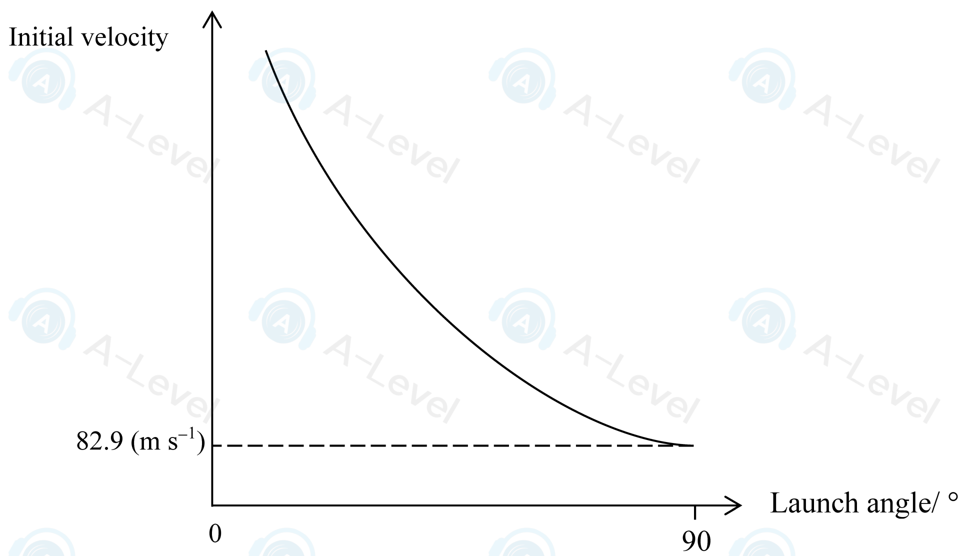
10	**C is the correct answer** A is not the correct answer as no indication in Q9 of extremely high velocity required to change displacement apparently instantly B is not the correct answer as lines straight, indicating no change in velocity D is not the correct answer as lines straight, indicating no change in velocity	(1)

4	The only correct answer is **C** C is correct because acceleration is 30/7.5 A is not correct because 0.53 is $30/7.5^2$ B is not correct because 2.0 is 30/(2×7.5) D is not correct because 8.0 is 2×30/7.5	1

3	**The only correct answer is D (The displacement at 4 hours divided by a time of 4 hours)** A is not correct because the area under a displacement-time graph has no significance B is not correct because this would give the instantaneous speed at the end of the marathon C is not correct because this would give the instantaneous speed at 2 hours	**1**

4	**B is the correct answer** A is not the correct answer as this would give a final velocity of 80 m s^{-1} N C is not the correct answer as this would give a final velocity of 120 m s^{-1} N D is not the correct answer as this would give a final velocity of 20 m s^{-1} S	**(1)**

5	**D is the correct answer** A is not the correct answer as the areas under the two graphs are not both zero. B is not the correct answer as the areas under the two graphs are not equal. C is not the correct answer as P is <u>at</u> the initial position.	**(1)**

Question Number	Answer		Mark
14(a)(i)	• Use of equation(s) of motion to determine u_v **Or** Use of $E_k = E_{grav}$ • $u_v = 83\ (\text{m s}^{-1})$ (for mp2 must have used $v = 0$ and $-g$) <u>Example of calculation</u> $0^2 = u^2 + 2(-9.81\ \text{m s}^{-2})\ (350\ \text{m})$ $u = 82.9\ \text{m s}^{-1}$	(1) (1)	2
14(a)(ii)	• Launch angle increasing as initial velocity decreases (i.e. negative gradient) • Curve drawn • Minimum initial velocity marked, and graph passes through (90, 82.9/80) **Or** other correct pair of points labelled and plotted • Initial velocity axis asymptotic  	(1) (1) (1) (1)	4
14(b)	(Perpendicular) distance to firework= time (counted) × speed of sound Diameter of firework = 2 × distance × tan (ϕ/2) (allow Diameter of firework = distance × tan (ϕ/2))	(1) (1)	2
	Total for question 14		**8**

Question Number	Answer	Mark
16(a)(i)	• Use $v^2 = u^2 + 2as$ **(1)** • $a = (-)\ 10.6\ (\mathrm{m\ s^{-2}})$ **(1)** <u>Example of calculation</u> $(75\ \mathrm{m\ s^{-1}})^2 = (460\ \mathrm{m\ s^{-1}})^2 + (2 \times a \times 9700\ \mathrm{m})$ $a = -\ 10.6\ \mathrm{m\ s^{-2}}$	**2**
16(a)(ii)	• Use of $F = ma$ **Or** $W = mg$ **(1)** • Use of $mg - F\cos 6 = ma$ **(1)** • $F = 8700$ N **(1)** (ecf from (a)(i), direction of a must be negative for MP2, $F = 8900$ N using the show that value) <u>Example of calculation</u> $600\ \mathrm{kg} \times (3.8\ \mathrm{N\ kg^{-1}}) - F\cos 6 = 600\ \mathrm{kg} \times (-10.6\ \mathrm{m\ s^{-2}})$ $F = 8690$ N	**3**

16(b)	**Either** • Free fall means that weight/gravity is the only force acting on the object/probe **(1)** • There will also be resistive forces acting on the probe **(1)** • Use $v^2 = u^2 + 2as$ to determine the acceleration **(1)** • $a = 2.4$ m s^{-2} **(1)** • Acceleration (of free-fall on Mars) = 3.8 (m s^{-2}) **(1)** • Comparison of their calculated acceleration to acceleration of free-fall with reason e.g. 2.4 m s^{-2} is lower than 3.8 m s^{-2} so it was not in free fall. **(1)** **Or** • Free fall means that weight/gravity is the only force acting on the object/probe **(1)** • There will also be resistive forces acting on the probe **(1)** • Use $v^2 = u^2 + 2as$ to determine the final velocity **(1)** • using $a = 3.8$ (m s^{-2}) **(1)** • $v = 181$ m s^{-1} **(1)** • Comparison of their calculated velocity to 150 m s^{-1} with reason **(1)** **Or** • Free fall means that weight/gravity is the only force acting on the object/probe **(1)** • There will also be resistive forces acting on the probe **(1)** • Use $v^2 = u^2 + 2as$ to determine the displacement **(1)** • Using $a = 3.8$ (m s^{-2}) **(1)** • $s = 2.4$ km **(1)** • Comparison of their calculated displacement to 3.7 km with reason **(1)** <u>Example of calculation</u> $(150 \text{ m s}^{-1})^2 = (68 \text{ m s}^{-1})^2 + (2 \times a \times 3700 \text{ m})$ $a = 2.42$ m s^{-2}	**6**
	Total for question 16	**11**

Question Number	Answer		Mark
15(a)	20 m s^{-1} is the average velocity **Or** the velocity is not constant **Or** the car is accelerating	(1)	
	Tangent drawn onto graph at t = 15 s **Or** use of correct equations of motion with u = 0	(1)	
	Velocity = 40 (m s^{-1})	(1)	**3**
	(Do not award MP2 for approximation of the curve to a straight line at 15 s) <u>Example of calculation</u> Gradient of tangent = $\frac{520\text{ m} - 100\text{ m}}{20.0\text{ s} - 10.5\text{ s}}$ = 44.2 m s^{-1}		
15(b)	The acceleration is decreasing **Or** the rate of change of velocity is decreasing	(1)	
	Drag forces are increasing (with increased velocity) **Or** the car is heading towards terminal velocity **Or** the resultant force is decreasing due (to the increasing drag force) **Or** air resistance is proportional to velocity (squared)	(1)	**2**
	Total for question 15		**5**

Question Number	Answer		Mark
14(a)	The ball fell a smaller distance (during each flash of the laboratory strobe) **Or** Each image of the ball would be smaller (using the laboratory strobe)	**(1)**	
	The uncertainty was less (with the laboratory strobe) MP2 dependent on MP1	**(1)**	**2**
14(b)(i)	(allow a for g throughout)		
	$s = (ut+)\frac{1}{2}gt^2$ **and** g is constant	**(1)**	
	Comparison of $s = \frac{1}{2}gt^2\ (+ut)$ with $y = mx\ (+c)$ **Or** s is proportional to t^2 so the gradient of graph is constant	**(1)**	**2**
14(b)(ii)	Use of $s = \frac{1}{2}at^2$ and a pair of corresponding values from the graph **Or** Pair of corresponding values from the graph used to determine gradient	**(1)**	
	g = 10.0 m s^{-2} (allow answers in the range 9.8 m s^{-2} to 10.1 m s^{-2}) (dependent on MP1) (answer must be consistent with their calculation)	**(1)**	**2**
	<u>Example of calculation</u> $\frac{\Delta h}{\Delta t^2} = \frac{0.30}{0.060} = 5.00$ $g = 5.00\text{ m s}^{-2} \times 2 = 10.00\text{ m s}^{-2}$		
	Total for question 14		**6**

14(a)	The ball fell a smaller distance (during each flash of the laboratory strobe) **Or** Each image of the ball would be smaller (using the laboratory strobe) The uncertainty was less (with the laboratory strobe) MP2 dependent on MP1	**(1)** **(1)**	**2**
14(b)(i)	(allow *a* for *g* throughout) $s = (ut+)\frac{1}{2}gt^2$ **and** *g* is constant Comparison of $s = \frac{1}{2}gt^2\ (+ut)$ with $y = mx\ (+c)$ **Or** *s* is proportional to t^2 so the gradient of graph is constant	**(1)** **(1)**	**2**
14(b)(ii)	Use of $s = \frac{1}{2}at^2$ and a pair of corresponding values from the graph **Or** Pair of corresponding values from the graph used to determine gradient $g = 10.0\ \text{m s}^{-2}$ (allow answers in the range 9.8 m s^{-2} to 10.1 m s^{-2}) (dependent on MP1) (answer must be consistent with their calculation) <u>Example of calculation</u> $\frac{\Delta h}{\Delta t^2} = \frac{0.30}{0.060} = 5.00$ $g = 5.00\ \text{m s}^{-2} \times 2 = 10.00\ \text{m s}^{-2}$	**(1)** **(1)**	**2**
	Total for question 14		**6**

Question Number	Answer		Mark
11	• Reference to $s = ut + \frac{1}{2} at^2$ with $u = 0$	**(1)**	
	• Correct variable labels on graph axes to give a straight line through origin.	**(1)**	
	• Reference to time in s and distance in m (this can be taken from the axes labels or a suitable unit conversion)	**(1)**	
	• Straight line through origin.	**(1)**	
	• Correct method to determine g using their graph.	**(1)**	**(5)**
	Total for question 11		**5**

Question Number	Answer		Mark
11	• Use of $a = \frac{v - u}{t}$	(1)	
	• See 1.6 m s^{-2} **Or** see (−)4.9 to (−)5.2 m s^{-2}	(1)	
	Max 1		
	• At 9 s the acceleration becomes negative	(1)	
	• From 9 s to 12 s the object is decelerating	(1)	
	• From 12 s to 17.5 seconds the object is accelerating while moving in the opposite direction	(1)	3
	Example of calculation $a = \frac{14 \text{ m s}^{-1} - 0}{9} = 1.56 \text{ m s}^{-2}$		
	Total for question 11		**3**